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ABSTRACT

This set of instructional materials provides secondary and postsecondary students with a state-of-the-art curriculum for the air conditioning and refrigeration industry that includes the many changes brought by new Environmental Protection Agency (EPA) regulations. Introductory materials explain the use of this publication and provide the following: competency profile; instructional/task analysis; related academic and workplace skills list; tools, equipment, and materials list; and reference list. Each of the 16 instructional units includes some or all of the following basic components: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, student supplements, assignment sheets, and job sheets. Units of instruction are designed for use in more than one lesson or class period of instruction. Unit titles are as follows: orientation; occupational safety; hand tools; special tools and measuring; tubing and tubing applications; iron, plastic, and PVC pipe; soldering, welding, and brazing equipment; soft soldering; silver brazing; aluminum soldering, brazing, and epoxy repair; basic mechanical refrigeration; refrigeration system accessories; EPA requirements for refrigerant management and technician certification; refrigerants, lubricants, and desiccants old and new; refrigerant recovery, recycling, and reclaiming; and evacuating, pressurizing, leak testing, and charging. (YLB)

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Fundamentals of Air Conditioning and Refrigeration

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Fundamentals of Air Conditioning and Refrigeration

Teacher Edition

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Disclaimer

This text presents information about the tools, equipment, and procedures required for the operation, maintenance, and repair of air conditioning and refrigeration systems. The information is intended for presentation and demonstration by an experienced instructor in a classroom/lab environment designed for the safety of students and equipment. Because training activities vary with local implementation the author and publisher disclaim liability for the use of these materials for other than their intended purposes.

Foreword

The EPA amendments to the Clean Air Act have changed air conditioning and refrigeration to such a degree that ACR service requires new equipment, new procedures, new refrigerants, and even new attitudes. *Fundamentals of Air Conditioning and Refrigeration* addresses all the new EPA regulations.

Important changes include the EPA regulations against carelessly venting refrigerant into the atmosphere, "de minimus" venting during ACR service, and recovery, recycling, and reclaiming so that refrigerant can be reused. The list is long because the job of phasing out ozone-depleting refrigerants is going to take a long time. But the regulations are here now, the new world of ACR service has already started, and *Fundamentals of Air Conditioning and Refrigeration* offers students sate-of-the-art curriculum for an industry facing the challenges of change.

Students who study ACR service must meet another important EPA regulation—they have to be certified by testing. Many programs are purchasing relatively expensive training materials for testing training. We think the *Fundamentals* text can provide the same service at a much more attractive price.

We hope these materials will not only update your program, but contribute to the quality of your program. However, instructors must still contribute significant elements to our efforts. The materials need to be localized and individualized. Most of all, students need to be motivated, and at this time when the industry itself is rapidly changing, students who learn well have a better prospect than ever of finding a really good paying job when school is over.

MAVCC appreciates hearing form people who use our materials. Call us at 1-800-654-3988 and share your opinions about *Fundamentals of Air Conditioning and Refrigeration*. We want to hear from you.

Dr. Harley Schlichting, Chairman MAVCC Board of Directors	Dr. Clark R. Harris MAVCC Executive Director

Acknowledgements

The resource committee which met to review and revise MAVCC's original air conditioning text was faced with an enormous challenge: all the new EPA regulations concerning refrigerants and the many changes those regulations brought to the entire ACR industry. For recognizing new training needs, we thank those instructors and industry members who provided outstanding direction for *Fundamentals of Air Conditioning and Refrigeration.*

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Use of Introductory Materials

Introductory materials are included in the teacher edition only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.
4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills and competencies being reinforced. Skill areas reflected by skill groups, sub skills, and definitions have been identified using *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.*
5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.
6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

A glossary of terms may also be provided in the introductory materials depending on subject matter and committee recommendations.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Fundamentals of Air Conditioning and Refrigeration contains 16 units of instruction. Each instructional unit in a teacher edition includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher edition. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher edition only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher edition only, but may be duplicated.

Use of This Publication

Teacher supplements (Color code: White)

This component is included only in the teacher edition. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher edition only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student edition. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher edition.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student editions contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

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National VICA Competencies
for
Fundamentals of Air Conditioning and Refrigeration

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Forthcoming national standards promise to mirror the HVACR Technician Competency List developed by the Vocational Industrial Clubs of America. The competencies are part of VICA's HVACR Professional Development Program developed with a grant from Sears Product Services. These materials demonstrate how MAVCC's *Fundamentals of Air Conditioning and Refrigeration* align with VICA's technician competencies. We hope that instructors and administrators responsible for program planning and evaluation will benefit from this national perspective.

VICA HVACR Technician Competency Checklist

A: Safety Principles

VICA Competency	MAVCC Unit	Specific Reference	Notes
1. Practice safe procedures when using tools and equipment	Unit 2 Occupational Safety	Objectives 1 thru 21 all treat matters of safety	Assignment Sheets 1, 2, and 3 require applications of safety procedures hands-on safety applications
2. Maintain organized, clean work area	Unit 2	Objectives 2, 3, and 4 address housekeeping and tool maintenance	Job Sheets 1 and 2 treat tool repair for safe maintenance
3. Identify safe work area	Unit 2	Objectives 9 and 10 treat signs and warnings	Assignment Sheets 1 and 2 test recognition of signs and warnings
4. Recognize value of personal safety and health	Unit 2	Objective 11 treats personal hygiene	Assignment Sheet 1 requires students to sign safety pledge
5. Demonstrate knowledge of CPR	Unit 2	Addressed in notes to instructor	Requires certified instructor
6. Demonstrate knowledge of first aid techniques	Unit 2	Objectives 14 and 15 cover general first aid at the job site	Assignment Sheet 2 requires evaluation of an MSDS
7. Demonstrate proper lifting techniques	Unit 2	Objective 10 lists equipment for safe lifting and safe lifting procedures	Application planned by instructor
8. Wear protective clothing, hearing cover, and eyewear	Unit 2	Objectives 18, 19, 20, and 21 treat OSHA's *Hazard Communication Standard* and *Bloodborne Pathogen Standard*	Assignment Sheet 2 requires completion of a worksheet about bloodborne pathogens
9. Complete accident report	Unit 2	Objective 11 treats accidents responses and reporting	Application planned by instructor
10. Demonstrate and practice knowledge of consumer protection	Unit 16	Objectives 2 and 20	Assignment Sheets 1 thru 21 require completion of a customer-oriented Service Work Order
11. Use, handle, and dispose of hazardous materials	Unit 2	Objective 18 treats OSHA's *Hazard Communication Standard* along with examples of MSDS materials	Assignment Sheet 1 requires students to interpret information form a material safety data sheet (MSDS)
12. Comply with regulations for handling refrigerants	Units 11, 12, 13, 14, and 15	Objectives in all units address EPA regulations for handling refrigerants and DOT regulations for handling cylinders	Many job sheets address both refrigerant and cylinder safety

VICA Competency	MAVCC Unit	Specific Reference	Notes
13. Maintain service tools, test equipment, and service vehicles	Units 3 through 16	Objectives in all units address tool and equipment safety for specific uses	Many job sheets stress safety for tools and equipment. Vehicle safety is presented in another MAVCC text.
14. Demonstrate methods of fire extinguishment	Unit 2	Objectives 8 and 9 present the fire triangle, classes of fires, and how to extinguish them	Application planned by instructor to enhance local fire prevention week.
15. Demonstrate knowledge of proper vehicle use/ demonstrate safe driving practices	Treated in other MAVCC text		
16. Maintain liability insurance	Treated in other MAVCC text		
17. Read maps/locate residences	Not specifically treated		Enhancement of materials provided by instructor for local application
18. Deal with household pets	Not specifically treated		Enhancement of materials provided by instructor for local applications
19. Demonstrate knowledge of OSHA color coding policies	Unit 2	Objectives 16, 17, and 18 treat safety colors, safety signs, and their applications	Application planned by instructor
20. Demonstrate knowledge of local codes and ordinances governing gas and electrical installations	Units 7, 8, and 9	Objectives reference the BOCA code that requires refrigerant lines be brazed instead of soldered	Job Sheets 1, 2, and 3 in Unit 9
21. Demonstrate knowledge of regulations for mobile home applications	Unit 5	Objective 13	Quick-connect fittings presented graphically and applications explained
22. Identify methods to remove a person from a live electrical circuit	No specific references		Application planned by instructor
23. Demonstrate discharge of electrostatic and charged devices	Referenced in other MAVCC texts		
24. Demonstrate use of ground-fault indicators	Referenced in other MAVCC texts		
25. Demonstrate loading/ securing/rigging apparatus	Unit 2	Objective 10	Demonstrates safe lifting with ladder and hoist-type dollie
26. Demonstrate knowledge of pathogens	Unit 2	Objectives 20 and 21 treat OSHA's *Bloodborne Pathogen Standard*	Assignment Sheet 2 requires students to complete a bloodborne pathogen worksheet
27. Demonstrate techniques to prevent personal injury (frostbite, electrical shock, cuts, etc.)	Unit 2	Objectives 2 through 5 treat lab, shop, machine, and solvent safety; Objectives 6, 12, 13, and 14 treat general electrical safety and safe use of electric tools	Applications reinforced in all assignment sheets; a student pledge requires students to acknowledge personal responsibility for both personal and equipment safety

VICA HVACR Technician Competency Checklist

B: Common Tools and Equipment Applications

VICA Competency	MAVCC Unit	Specific Reference	Notes
1. Practice safe operation and use of hand drills, saws, and cordless drills and drivers	Unit 4	Objectives 2 and 3 treat use and care	Assignment Sheet 1 requires student to identify specific equipment
2. Wear protective clothing/ safety goggles and ear protection as prescribed by OSHA regulations when using specified tools, applications, and/or supplies	Units 3 and 4	Objectives 12 and 13, Unit 3, Objectives 2, 3, 4, and 5, Unit 4	Job Sheets 1 and 2, Unit 4 require personal safety gear for grinding and machine safety specifications
3. Demonstrate application of pads and protective devices	No specific references		Application planned by instructor
4. Demonstrate knowledge of and application of basic hand tools (standard and metric)	Unit 3	Objectives 1 thru 13	Application planned by instructor. Assignment Sheet 1 requires students to identify selected hand tools.
5. Demonstrate application of tap and die threading devices	Unit 6	Objectives 2 and 3 treat black iron and galvanized pipe in HVACR applications	Job Sheet 2 requires students to cut, ream, and thread iron pipe
6. Demonstrate knowledge and use of cutting tools, chisels, saws, and punches	Unit 3	Objective 6 treats punches, chisels, bars, and their uses; Objective 10 treats threading tools and their uses	Tools applied in Job Sheet 2 of Unit 6; Assignment Sheet 1 this unit, also requires identification of tools and written description of their uses
7. Demonstrate knowledge and use of hand drills, saws, and cordless drills and drivers	Unit 4	Objective 2	Applications vary with job sheets in several other units
8. Demonstrate the use of electric and hand impact wrenches	No specific references		Referenced in another MAVCC text
9. Use heat gun	No specific references		Reference in another MAVCC text
10. Use shop rags	Various units	Various objectives	Shop rags are included as part of materials needed for all job sheets; used for clean-up in soldering and brazing; used for protecting from refrigerant skin damage in line service
11. Use vacuum cleaners	No specific references		Application planned by instructor
12. Use cleaners, solvents, and lubricants	Several units	Several objectives and many job sheets	Cleaners required in soldering and brazing, Unit 8 and 9; Solvents used with PVC in Unit 6, job Sheet 1; Lubricants used throughout service procedures in Units 13, 14, 15, and 16

VICA Competency	MAVCC Unit	Specific Reference	Notes
13. Use test cords and power extensions	Unit 2	Objective 6	Specific rules for power cords and extensions in the workplace
14. Demonstrate ability to safely move equipment	Unit 2	Objective 10	Illustrates and defines how to lift and move ladders, how to use hoist-type dollie to move heavy equipment
15. Demonstrate knowledge of heating, ventilation, and air conditioning and refrigeration special tool applications	Various units	Various objectives	Refrigeration ratchet part of equipment list on all system service job sheets in Units 13, 14, 15, and 16; other specialized tools presented with applications of leak checking, charging, etc.

C: Tubing and Piping

VICA Competency	MAVCC Unit	Specific Reference	Notes
1. Identify tubing types and fitting	Unit 5	Objective 2 treats kinds of tubing and their applications; Objective 8 treats types of tubing fittings	Assignment Sheet 1 requires students to identify selected fittings for tubing
2. Demonstrate cutting, flaring, swaging, and bending tubing	Unit 5	Objectives 14, 15, 16, and 17 treat cutting, flaring, swaging, and bending tubing	Job Sheets 1 and 2 require students to flare with different type flaring blocks; Job Sheets 3 thru 6 require students to make a swage joint and bend tubing at 45°, 90°, and 180°.
3. Identify piping type and fittings	Unit 6	Objectives 1, 2, and 3 treat black iron, galvanized, and polybutylene and polyethylene	Job Sheets 1, 2, and 3 require students to cut, ream, and join PVC, cut, ream, and thread iron pipe, and join flexible pipe with butt fusion
4. Cut, prepare, and assemble metallic pipe	Unit 6	Objectives 5 and 6 treat iron and brass fittings; Objective 11 treats ways to measure pipe; Objective 13 treats a pipe threading chart	Job Sheet 2 requires students to cut, ream, and thread iron pipe
5. Cut, prepare, and assemble non-metallic pipe	Unit 6	Objective 4 treats non-metallic pipe, PB and PE in diaelectric unions and gas line installations; Objective 10 treats PE diaelectric unions	Applications planned by instructor pending local availabilities
6. Demonstrate application of specialized pipe and tubing tools	Unit 6	Objective 7 treats the use of flexible pipe fittings; Objective 8 treats PVC fittings; Objective 14 treats tools for working with PVC	

D: Soldering and Brazing

VICA Competency	MAVCC Unit	Specific Reference	Notes
1. Practice safe operating procedure when performing soldering and brazing operations	Units 7, 8, and 9	Almost all objectives in all 3 units stress safety in handling gases, lighting torches, and safe shut down	Job Sheets 1, 2, and 3 in Unit 7 require students to safely light, adjust and shut down air-acetylene and oxy-acetylene equipment

VICA HVACR Technician Competency Checklist

VICA Competency	MAVCC Unit	Specific Reference	Notes
2. Demonstrate knowledge and application of soldering, brazing, and welding materials and torches	Units 7, 8, 9, and 10	Almost all objectives in all 4 units stress proper tubing preparation, flux application, torch safety, torch techniques, and clean up	Job sheets in Unit 8 require students to solder; job sheets in Unit 9 require students to braze, job sheets in Unit 10 require students to repair aluminum with solder and with paste and stick epoxy
3. Join similar and dissimilar metals	Unit 9	Objective 2 treats problems of repairing aluminum and special considerations	Job Sheet 2 requires student to silver braze a copper-to-steel joint
4. Use heat transfer compounds	Unit 8	Objective 7 treats ways to control heat while soldering	Objective illustrates the use of a wet shop cloth as a heat barrier and the use of a blocking paste as a heat barrier

E: Refrigeration Systems

VICA Competency	MAVCC Unit	Specific Reference	Notes
1. Practice safe operating procedures	All units	All applications job sheets	All job sheets require student to wear safety glasses, colored safety glasses for soldering/brazing, and to maintain a clean workplace
2. Demonstrate knowledge of heat and heat transfer	Unit 11	Objective 3 treats the laws of thermodynamics and gases	
3. Demonstrate knowledge of pressure and temperature	Unit 16	Objective 9 treats pressure/temperature requirements for dehydration	Job Sheet 14 requires students to use superheat parameters to check a thermostatic expansion valve; Job Sheet 21 requires students to evaluate a system charge using pressure/temperature parameters
4. Demonstrate knowledge of states of matter (solids, liquids, and gases)	Unit 11	Various objectives	Assignment Sheet 2 requires students to identify points in a system where gases change state
5. Demonstrate knowledge of pressure/temperature effects on state of matter	Unit 11	Objectives 2 thru 9	Student is tested on component functions with respect to states of matter as a refrigerant moves in a cycle through a refrigeration system
6. Demonstrate knowledge of basic compression refrigeration cycle	Unit 11	All objectives and 3 assignment sheets	Students tested on component alignment and function for metering device, evaporator, suction line, condenser, and liquid line; Assignment Sheet 3 requires student to find these components on selected systems

VICA Competency	MAVCC Unit	Specific Reference	Notes
7. Demonstrate knowledge of refrigerants and their properties	Units 13, 14, 15, and 16	Objective 7, Unit 13 lists EPA regulated refrigerants; all objectives in Unit 14 are dedicated to traditional and alternative refrigerants including drop-ins and retrofits, and blends with "bubble points" and "dew points"	Job Sheets 1, 2, and 3 require a student to pressure check a domestic refrigeration system, a residential air conditioner, and a commercial refrigeration system
8. Demonstrate knowledge of manifold gauge set	Unit 14	objective 7 and 8 treat related matters of pressure/temperature	Job Sheet 1 requires students to attach a manifold gauge set to service port, and there are more than 20 more job sheets that require students to use a manifold gauge set
9. Demonstrate knowledge of system access	Units 12, 13, 14, 15, and 16	Objectives in Unit 12 define types of access valves including king valves	Job Sheet 1 in Unit 16 requires students to install a line tap access valve, and Job Sheet 15 in unit 16 requires students to install a core-type access valve; all other job sheets in Unit 16 require students to access a system for some form of service
10. Demonstrate knowledge of refrigeration components (compressor, condenser, metering device, and evaporator)	Unit 11	All objectives dedicated to components identification with explanations of their functions in the system and a refrigeration cycle; objectives are well illustrated	Assignment Sheet 1 requires students to identify components in a graphic, and Job Sheet 1 requires students to physically find and identify basic components on refrigeration and air conditioning systems
11. Demonstrate knowledge of refrigeration accessories	Unit 12	All objectives dedicated to accessory identification with explanations of their functions in a system; objectives are well illustrated	Assignment Sheet 1 requires students to identify accessories in a graphic, and Job Sheet 1 requires students to physically find and identify accessories on selected systems
12. Demonstrate knowledge of automatic expansion valves	Unit 11	Objective 6 treats types of metering devices and their characteristics	
13. Demonstrate knowledge of electronic expansion valves	Unit 11	Objective 6 treats types of metering devices and their characteristics	
14. Demonstrate knowledge of thermostatic expansion valves	Units 11 and 16	Objective 6 treats types of metering devices and their characteristics	Job Sheet 8, Unit 16, requires students to install a thermostatic expansion valve with flare fittings and adjust it to mfg's specifications
15. Demonstrate knowledge of fixed orifice metering devices	Units 11 and 16	Objective 6 treats types of metering device and their characteristics	Job Sheet 2, Unit 16, requires students to install a filter-drier on a capillary tube
16. Install dryers (liquid and suction line service)	Units 15 and 16	Objective 18, Unit 15, shows students how to make an in-line filter	Job Sheet 2, Unit 16 requires students to install a filter-drier on a capillary tube; Job Sheet 16 requires students to install a filter-drier with sweat fittings; Job Sheets 1, 2, and 3 in Unit 15 require handling filters in recycling service

VICA HVACR Technician Competency Checklist

VICA Competency	MAVCC Unit	Specific Reference	Notes
17. Install mufflers	Unit 12	Objective 5 treats noise and vibration control in large systems	Application planned by instructor according to local availability
18. Install sight glasses and moisture indicators	Unit 16	Objective 19 treats special conditions for liquid and vapor charging including monitoring a sight glass	Job Sheet 9 requires students to install a liquid indicator with flare fittings
19. Install liquid line solenoids	No specific reference		
20. Install not gas bypass valve	No specific reference		
21. Install evaporator pressure regulating valves	No specific reference		
22. Install crankcase regulating valves	No specific reference		
23. Install suction line accumulators	Unit 12	Objective 3 treats suction line accumulators and their characteristics	Application planned by instructor according to local availabilities
24. Install liquid line heat exchangers	No specific reference		
25. Install oil separators	Unit 15	General references	Some job sheets show oil separator use in recycling equipment
26. Install water regulating valves	No specific reference		
27. Install check valves	Unit 12	Objective 8 treats service valves and their characteristics	Applications planned by instructor according to local availabilities
28. Demonstrate knowledge of pressurizing and leak testing	Unit 16	Objective 5 treats guidelines for pressurizing a system, and Objectives 6 and 7 treat leak testing with soap solution, halide torch, and electronic leak detector	Job Sheet 3 requires students to pressurize a system with refrigerant and dry nitrogen; Job Sheet 4 requires students to leak test with a halide torch; Job Sheet 11 requires students to pressurize a system with dry nitrogen and leak test; Job Sheet 17 requires students to leak test with an electronic leak tester
29. Demonstrate knowledge of refrigerant recovery/recycle equipment	Unit 15	All objectives dedicated to recovery, recycling, and reclaiming	Job Sheet 1 requires students to use a hand pump to recover refrigerant from a small AC or refrigeration system; Job Sheet 2 requires students to recover refrigerant from an AC or refrigeration system; Job Sheet 3 requires students to use a recovery/recycling machine to recover/recycle refrigerant from an AC or refrigeration system

VICA Competency	MAVCC Unit	Specific Reference	Notes
30. Demonstrate knowledge of system cleaning and evacuation procedures	Unit 16	Objectives 1 and 2 treat how to prepare a system for operation and how to remove refrigerant and other gases; Objective 14 treats guidelines for evacuation	Job Sheet 12 requires students to triple evacuate a system; Job Sheet 18 requires students to evacuate a system
31. Charge system according to manufacturer's standards	Unit 16	Objective 15 treats characteristics of charging equipment; Objective 16 treats using weight or volume for charging; Objective 17 treats using a sight glass for charging; Objective 18 treats using a superheat table for charging; Objective 19 treats special conditions for liquid and vapor charging	Job Sheet 19 requires students to charge using a charging cylinder; Job Sheet 20 requires a student to vapor charge from a refrigerant cylinder; Job Sheet 21 requires students to use suction line temperature/pressure to evaluate a system charge
32. Evaluate system performance in accordance with manufacturer's standards	Unit 16	Objective 21 treats procedures for preparing a small refrigeration system for operation; Objective 22 treats procedures for preparing a refrigeration system with a thermostatic expansion valve; Objective 23 treats preparing a system with a fixed metering device	Job Sheet 14 requires students to check and adjust a thermostatic expansion valve using superheat parameters; Job Sheet 21 requires students to use suction line temperature/pressure parameters to evaluate a system charge
33. Use psychrometric charts	No specific reference in this text	MAVCC's *Residential and Light Commercial HVAC*	An entire unit dedicated to psychrometrics and applications of psychrometric charts in planning and evaluating systems

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SCANS Foundational Skills and Competencies

Skill Groups	Sub Skills	Definitions
Basic Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Arithmetic/mathematics	Performing basic computations, applying, estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques
	Science	Applying knowledge learned through study or practice that is based on scientific principles, methods, and techniques
	Listening	Receiving, interpreting, and responding to verbal messages and other cues.
	Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
Thinking Skills	Creative thinking	Using imagination to generate new ideas.
	Decision making	Specifying goals and constraints, generating alternatives, considering risks and evaluating and choosing the best alternative.
	Problem solving	Recognizing and defining problems, devising and implementing plan of action and tracking and evaluating results.
	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills.
	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
Personal Management Skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
	Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Career awareness, development and mobility	Assessing self accurately, setting personal goals, establishing and implementing a plan, and monitoring progress.
	Integrity/honesty	Choosing an ethical course of action when faced with making a decision that may break with personal or societal values and recognizing the impact of violating these beliefs and codes on an organization, self, and others.
	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.

Skill Groups	Sub Skills	Definitions
Resources	Time	Selecting relevant, goal-related activities, ranking them in order of importance, allocating time, and understanding, preparing, and following schedules.
	Money	Using or preparing budgets, making forecasts, keeping records, and making adjustments to meet objectives.
	Material and facilities	Acquiring, storing, and using materials space efficiently.
	Human resources	Assessing skills and distributing work accordingly, evaluating performance and providing feedback.
Interpersonal Skills	Teamwork	Working cooperatively with others to reach a common goal.
	Coaching	Helping others learn new skills.
	Leadership	Communicating ideas to justify position, accepting responsibility for others, and encouraging, persuading, convincing, or otherwise motivating an individual or group.
	Negotiation	Resolving conflict between two or more individuals through discussion and compromise.
	Customer service	Working and communicating with customers to satisfy their expectations.
	Cultural diversity	Working well with men and women and with a variety of ethnic, social, or educational backgrounds.
Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Organization and storage	Organizing, processing, and maintaining written or computerized records and other forms of information in a systematic way.
	Interpretation	Selecting and analyzing information and communicating the results to others.
	Processing	Using computers to acquire, organize, analyze, and communicate information.
Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
	Monitoring	Distinguishing trends, predicting impact of actions on system operations, diagnosing deviations in systems' performance and correcting malfunctions.
	Modification and design	Making suggestions to modify existing systems to improve products or services, and developing new or alternative systems.
Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
	Application	Demonstrating proper procedures for setting up and operating equipment.
	Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.

Fundamentals of Air Conditioning and Refrigeration

Competency Profile

Name: ______________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale: 4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: Orientation

______ 1. Locate local and area companies that employ air conditioning and refrigeration technicians.
______ 2. ______________________________

______Written Test Score

Unit 2: Occupational Safety

______ 1. Interpret important information from a materials safety data sheet.
______ 2. Complete a worksheet about bloodborne pathogens.
______ 3. Complete a student safety pledge.
______ 4. ______________________________

______Written Test Score

Unit 3: Hand Tools

______ 1. Identify selected hand tools and describe their uses.
______ 2. ______________________________

______Written Test Score

Unit 4: Special Tools and Measuring

______ 1. Measure lines to the nearest quarter, eighth, and sixteenth of an inch.
______ 2. Read a rule.
______ 3. Measure selected items with slide calipers.
______ 4. Grind the head of a chisel or punch.
______ 5. Sharpen a chisel or screwdriver.
______ 6. ______________________________

______Written Test Score

Unit 5: Tubing and Tubing Applications

______ 1. Identify selected fittings for copper tubing.
______ 2. Make a single flare with a compression-type flaring block.
______ 3. Make a single flare with a Rol-Air® type flaring block.
______ 4. Make a swage joint in copper tubing.
______ 5. Make a 90° bend in copper tubing.
______ 6. Make a 180° bend in copper tubing.
______ 7. Make a 45° offset bend in copper tubing.
______ 8. ______________________________

______Written Test Score

Unit 6: Iron, Plastic, and PVC Pipe

______ 1. Cut and ream PVC pipe and join it to a fitting.
______ 2. Cut, ream, and thread iron pipe.
______ 3. Join flexible pipe with a butt fusion process.
______ 4. ______________________________

______Written Test Score

Unit 7: Soldering, Welding, and Brazing Equipment

______ 1. Light, adjust, and shut down an air-acetylene torch.
______ 2. Light, adjust, and shut down an air-acetylene torch with a swirl tip.
______ 3. Light, adjust, and shut down an oxyacetylene welding/brazing torch.
______ 4. ______________________________

______Written Test Score

Unit 8: Soft Soldering

______ 1. Use an air-acetylene torch to solder copper tubing/swage joints in upright, horizontal, and inverted positions.
______ 2. Use an oxyacetylene torch to solder tubing/swage joints in upright, horizontal, and inverted positions.
______ 3. ______________________________

______Written Test Score

Competency Profile

Unit 9: Silver Brazing

______ 1. Silver braze upright, inverted, and horizontal swage joints.
______ 2. Silver braze a copper-to-steel joint.
______ 3. Silver braze a copper tubing project.
______ 4. ____

______Written Test Score

Unit 10: Aluminum Soldering, Brazing, and Epoxy Repair

______ 1. Soft solder an aluminum tubing/swage joint with an air-acetylene torch.
______ 2. Repair a hole in aluminum tubing with brazing and an air-acetylene torch.
______ 3. Repair a hole in aluminum tubing with paste epoxy.
______ 4. Repair a pin-hole leak in aluminum tubing with a pre-mixed two-part epoxy stick.
______ 5. Solder aluminum tubing to copper tubing.
______ 6. ____

______Written Test Score

Unit 11: Basic Mechanical Refrigeration

______ 1. Identify components of a basic mechanical refrigeration system.
______ 2. Select component functions in a basic refrigeration cycle.
______ 3. Find and identify basic refrigeration components.
______ 4. ____

______Written Test Score

Unit 12: Refrigeration System Accessories

______ 1. Identify components of a mechanical refrigeration system with accessories.
______ 2. Select functions for refrigeration system accessories.
______ 3. Select operating positions for service valves.
______ 4. Find and identify refrigeration system accessories.
______ 5. ____

______Written Test Score

Unit 13: EPA Requirements for Refrigeration Management and Technician Certification

______ 1. Answer sample certification test questions.
______ 2. ____

______Written Test Score

Unit 14: Refrigerants, Lubricants, and Desiccants Old and New

______ 1. Compute temperature/pressure relationships.
______ 2. Attach a manifold gauge set to service ports.
______ 3. Pressure check a domestic refrigeration system.
______ 4. Pressure check a residential air conditioning system.
______ 5. Pressure check a commercial refrigeration system.
______ 6. ____

______Written Test Score

Unit 15: Refrigerant Recovery, Recycling, and Reclaiming

______ 1. Use a hand-operated pump to recover refrigerant from a small AC or refrigeration system.
______ 2. Use a recovery machine to recover refrigerant from an AC or refrigeration system.
______ 3. Use a recovery/recycling machine to recover/recycle refrigerant from an AC or refrigeration system.
______ 4. ____

______Written Test Score

Unit 16: Evacuating, Pressurizing, Leak Testing, and Charging

______ 1. Complete Service Work Order 1.
______ 2. Complete Service Work Order 2.
______ 3. Complete Service Work Order 3.
______ 4. Install a line tap access valve.
______ 5. Install a filter-drier on a capillary tube.
______ 6. Pressurize a refrigeration system with refrigerant and dry nitrogen.
______ 7. Leak check with a halide torch.
______ 8. Evacuate a refrigeration system and verify level with a micron gauge.
______ 9. Fill a charging cylinder.
______10. Vapor charge a refrigeration system from a charging cylinder.
______11. Install a thermostatic expansion valve with flare fittings.
______12. Install a liquid indicator with flare fittings.
______13. Install a filter-drier with flare fittings.
______14. Pressurize a system with dry nitrogen and leak test.
______15. Triple evacuate a refrigeration system.
______16. Liquid charge a refrigeration system from a refrigerant cylinder.
______17. Check and adjust a thermostatic expansion valve using superheat parameters.
______18. Install a core-type access valve.
______19. Install a filter-drier with sweat fittings.
______20. Leak test a refrigeration system with an electronic leak detector.
______21. Evacuate a refrigeration system.
______22. Liquid charge using a charging cylinder.
______23. Vapor charge a refrigeration system from a refrigerant cylinder.

Competency Profile

______24. Use suction line temperature/pressure parameters to evaluate a system charge.

______25. ____

______Written Test Score

COMMENTS: ____

____

____

____

____

Evaluator: ______________________ Date: ______________________

*** Permission to duplicate this profile is granted.**

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Fundamentals of Air Conditioning and Refrigeration

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Orientation

1. Terms and definitions
2. ACR manufacturing jobs and their training requirements
3. ACR wholesaling jobs and their training requirements
4. ACR service and installation jobs and their training requirements
5. ACR building maintenance jobs and their training requirements
6. Future opportunities for ACR technicians
7. Locate local and area companies that employ air conditioning and refrigeration technicians. (Assignment Sheet 1)

Unit 2: Occupational Safety

1. Terms and definitions
2. Guidelines for personal lab safety
3. Guidelines for general shop safety
4. Guidelines for machine safety
5. Guidelines for solvent safety
6. Guidelines for workplace electrical safety
7. Characteristics of a clean and orderly shop
8. The fire triangle
9. Classes of fires and ways to put them out
10. Procedures for safe lifting

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: (continued)

11. Guidelines for handling an accident
12. Circuit amperages and their affects on the human body
13. Guidelines for general electrical safety
14. Guidelines for using electrical tools
15. Safety colors and their applications
16. Accident prevention signs, their colors and applications
17. Accident prevention signs, their colors and applications
18. OSHA's *Hazard Communication Standard*
19. Ways to protect yourself from hazardous substances in the workplace
20. OSHA's *Bloodborne Pathogen Standard*
21. Other items related to the *Bloodborne Pathogen Standard*

22. Interpret important information from a materials safety data sheet. (Assignment Sheet 1)
23. Complete a worksheet about bloodborne pathogens. (Assignment Sheet 2)
24. Complete a student safety pledge. (Assignment Sheet 3)

Unit 3: Hand Tools

1. Terms and definitions
2. Types of screwdrivers and their uses
3. Types of wrenches and their uses
4. Types of pliers and their uses
5. Types of hammers and their uses
6. Punches, chisels, bars, and their uses

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 3: (continued)

7. Types of files and their uses
8. Socket sets and their uses
9. Tubing tools and their uses
10. Threading tools and their uses
11. Hand tools and their uses
12. Guidelines for using basic hand tools safely
13. Guidelines for using other hand tools safely

14. Identify selected hand tools and describe their uses. (Assignment Sheet 1)

Unit 4: Special Tools and Measuring

1. Terms and definitions
2. Working with drills and power screwdrivers
3. Use and care of grinders and vises
4. Use and care of pullers
5. Caring for drilling tools
6. Use and care of thermometers
7. Use and care of hygrometers
8. The use of sheet metal tools in ACR work
9. Guidelines for measuring distances
10. Reading a rule
11. Metrics in the American workplace

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 4: (continued)

12. Interpolating with math and measuring
13. Decimal equivalents and their applications
14. Measuring and converting pressure readings
15. Measuring and converting vacuum readings
16. Measuring and converting weight readings
17. Measuring Btu and Btuh

18. Measure lines to the nearest quarter, eighth, and sixteenth of an inch. (Assignment Sheet 1)
19. Read a rule. (Assignment Sheet 2)
20. Measure selected items with slide calipers. (Assignment Sheet 3)
21. Grind the head of a chisel or punch. (Job Sheet 1)
22. Sharpen a chisel or a screwdriver. (Job Sheet 2)

Unit 5: Tubing and Tubing Applications

1. Terms and definitions
2. Kinds of tubing and their applications
3. Advantages of copper tubing in ACR applications
4. Characteristics of type K copper tubing and its applications
5. Characteristics of type L copper tubing and its applications
6. Characteristics of type M copper tubing and its applications
7. DWV tubing and its applications
8. Tubing fittings and their characteristics
9. Flare fittings
10. Flare-to-pipe fittings
11. Compression fittings

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 5: (continued)

12. Sweat fittings
13. Quick connect fittings and their applications
14. Guidelines for cutting and reaming tubing
15. Guidelines for flaring tubing
16. Guidelines for swaging tubing
17. Tools for bending tubing

18. Identify selected fittings for copper tubing. (Assignment Sheet 1)
19. Make a single flare with a compression-type flaring block. (Job Sheet 1)
20. Make a single flare with a Rol-Air® type flaring block. (Job Sheet 2)
21. Make a swage joint in copper tubing. (Job Sheet 3)
22. Make a 90° bend in copper tubing. (Job Sheet 4)
23. Make a 180° bend in copper tubing. (Job Sheet 5)
24. Make a 45° offset bend in copper tubing. (Job Sheet 6)

Unit 6: Iron, Plastic, and PVC Pipe

1. Terms and definitions
2. Black iron in HVAC applications
3. Galvanized iron in HVAC applications
4. Polybutylene and polyethylene in HVAC applications
5. Using iron pipe fittings
6. Using brass fittings
7. Guidelines for using flexible plastic fittings
8. Guidelines for using PVC fittings

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 6: (continued)

9. Guidelines for working with polybutylene and polyethylene
10. Using PE dielectric unions in HVAC applications
11. Guidelines for measuring pipe
12. Tools for cutting and threading iron pipe
13. What a pipe threading chart shows
14. Tools for working with PVC

15. Cut and ream PVC pipe and join it to a fitting. (Job Sheet 1)
16. Cut, ream, and thread iron pipe. (Job Sheet 2)
17. Join flexible pipe with a butt fusion process. (Job Sheet 3)

Unit 7: Soldering, Welding, and Brazing Equipment

1. Terms and definitions
2. Soldering, brazing, and welding parameters
3. Characteristics and components of an air-acetylene torch
4. Torch tip design for soldering and brazing
5. Self-lighting torch designs for soldering and brazing
6. Types of acetylene tanks and their applications
7. Guidelines for lighting, adjusting, and shutting down an air-acetylene torch
8. Equipment needed for oxyacetylene welding and brazing
9. Regulating valves and adjusting screws
10. Oxyacetylene hoses and their characteristics

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 7: (continued)

11. Parts of a welding/brazing torch
12. Oxyacetylene welding/brazing tips and their uses
13. Filler materials for oxyacetylene welding/brazing
14. Tip cleaning tools and their uses
15. Guidelines for cleaning tips
16. Eye protection required for oxyacetylene welding/brazing
17. Steps for setting up oxyacetylene equipment
18. Steps for lighting, adjusting, and shutting down an oxyacetylene torch
19. Safety guidelines for flashback and backfire
20. Safety rules for oxyacetylene cylinders and gases

21. Light, adjust, and shut down an air-acetylene torch. (Job Sheet 1)
22. Light, adjust, and shut down an air-acetylene torch with a swirl tip. (Job Sheet 2)
23. Light, adjust, and shut down an oxyacetylene welding/brazing torch. (Job Sheet 3)

Unit 8: Soft Soldering

1. Terms and definitions
2. General characteristics of solder
3. The importance of flux in the soldering process
4. Problems about selecting and applying flux
5. Torch techniques for good soldering
6. Special considerations for soldering

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 8: (continued)

7. Ways to control heat while soldering
8. Soldering problems and ways to detect them
9. Soldering and brazing safety
10. Use an air-acetylene torch to solder copper tubing/swage joints in upright, horizontal, and inverted positions. (Job Sheet 1)
11. Use an oxyacetylene torch to solder tubing/swage joints in upright, horizontal, and inverted positions. (Job Sheet 2)

Unit 9: Silver Brazing

1. Terms and definitions
2. Basic silver solder alloys
3. Special brazing alloys and their characteristics
4. Brazing fluxes and their applications
5. Controlling brazing oxides with nitrogen
6. Silver braze upright, inverted, and horizontal swage joints. (Job Sheet 1)
7. Silver braze a copper-to-steel joint. (Job Sheet 2)
8. Silver braze a copper tubing project. (Job Sheet 3)

Unit 10: Aluminum Soldering, Brazing, and Epoxy Repair

1. Terms and definitions
2. Considerations for aluminum repairs
3. Aluminum repair with epoxy paste
4. Aluminum repairs with pre-mixed epoxy sticks
5. Steps for using the aluminum brazing rod
6. Steps for using aluminum soft solder
7. Soft solder an aluminum tubing/swage joint with and air-acetylene torch. (Job Sheet 1)
8. Repair a hole in aluminum tubing with brazing and an air-acetylene torch. (Job Sheet 2)
9. Repair a hole in aluminum tubing with paste epoxy. (Job Sheet 3)
10. Repair a pin-hole leak in aluminum tubing with a pre-mixed two-part epoxy stick. (Job Sheet 4)
11. Solder aluminum tubing to copper tubing. (Job Sheet 5)

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 11: Basic Mechanical Refrigeration

1. Terms and definitions
2. Refrigeration system components and their functions
3. How laws for thermodynamics and gases work in a refrigeration cycle
4. Reciprocating compressors and their applications
5. Other compressors and their applications
6. Types of metering devices and their characteristics
7. Type of condensers and their characteristics
8. Types of evaporators and their characteristics
9. System design and sensory troubleshooting

10. Identify components of a basic mechanical refrigeration system. (Assignment Sheet 1)
11. Select components functions in a basic refrigeration cycle. (Assignment Sheet 2)
12. Find and identify basic refrigeration components. (Job Sheet 1)

Unit 12: Refrigeration System Accessories

1. Terms and definitions
2. Refrigeration system accessories and their functions
3. Suction line accumulators and their applications
4. Oil separators and their applications
5. Noise and vibration control with large compressors
6. Filter-driers

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 12: (continued)

Related Information: What the Student Should Know

7. Monitoring moisture and liquid in a system
8. Service valves and their operating characteristics
9. Guidelines for using service valves
10. Other refrigeration valves and their applications
11. Shut-off valves and their applications

Application: What the Student Should Be Able to Do

12. Identify components of a mechanical refrigeration system with accessories. (Assignment Sheet 1)
13. Select functions for refrigeration system accessories. (Assignment Sheet 2)
14. Select operating positions for service valves. (Assignment Sheet 3)
15. Find and identify refrigeration system accessories. (Job Sheet 1)

Unit 13: EPA Requirements for Refrigeration Management and Technician Certification

1. Terms and definitions
2. Important historical information about ozone
3. The ozone-depletion cycle and its causes
4. Types of global warming and how it is measured
5. Ozone depletion and what it means
6. Human environmental concerns about ozone depletion
7. Regulated refrigerants
8. The prohibition on venting
9. Permitted releases under the "no venting" regulation
10. Service practice requirements
11. Refrigerant leaks and repair requirements

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 13: (continued)

12. Certification procedures

13. Contents and conduct of certification tests

14. Training for EPA certification

15. Answer sample certification test questions. (Assignment Sheet 1)

Unit 14: Refrigerants, Lubricants, and Desiccants Old and New

1. Terms and definitions

2. Problems and challenges for an industry in transition

3. The EPA SNAP program and its objectives

4. Traditional refrigerants and their characteristics

5. Characteristics of blended refrigerants

6. How to avoid potential problems with new refrigerants

7. Gauges, charts, and pressure/temperature relationships

8. Why pressure/temperature relationships are important

9. Charging a system with a blend

10. "Drop in" and "retrofit" alternative refrigerants

11. Bubble point and dew point and what they mean

12. ACR lubricants and their characteristics

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 14: (continued)

13. Guidelines for adding or changing lubricants
14. Working with synthetic oils
15. Desiccants, their characteristics and uses
16. Refrigerant identification colors and numbers

17. Compute temperature/pressure relationships. (Assignment Sheet 1)
18. Attach a manifold gauge set to service ports. (Job Sheet 1)
19. Pressure check a domestic refrigeration system. (Job Sheet 2)
20. Pressure check a residential air conditioning system. (Job Sheet 3)
21. Pressure check a commercial refrigeration system. (Job Sheet 4)

Unit 15: Refrigerant Recovery, Recycling, and Reclaiming

1. Terms and definitions
2. General requirements for recovery, recycling, and reclaiming
3. Self-contained and system-dependent recovery
4. Recovery and recycling safety
5. ARI Standard 700 and its applications
6. Guidelines for using DOT 39 disposable refrigerant cylinders
7. Guidelines for using refillable cylinders
8. Basic recovery devices
9. Basic recovery processes
10. EPA required evacuation practices during recovery
11. Special considerations for disposing of small appliances

Instructional/Task Analysis

Unit 15: Basic Mechanical Refrigeration

Related Information: What the Student Should Know

12. Recycling equipment and processes
13. The reclaiming process
14. Guidelines for effective recovery
15. Improperly mixed refrigerants and how to avoid them
16. Recovery system characteristics and their applications
17. Recovery/recycling characteristics
18. How to make an in-line filter

Application: What the Student Should Be Able to Do

19. Use a hand-operated pump to recover refrigerant from a small AC or refrigeration system. (Job Sheet 1)
20. Use a recovery machine to recover refrigerant from an AC or refrigeration system. (Job Sheet 2)
21. Use a recovery/recycling machine to recover/recycle refrigerant from an AC or refrigeration system. (Job Sheet 3)

Unit 16: Evacuating, Pressurizing, Leak Testing, and Charging

1. Terms and definitions
2. Preparing a refrigeration system for operation
3. Removing refrigerant and other gases
4. Guidelines for assembling components
5. Guidelines for pressurizing a system
6. Leak testing with soap solution
7. Leak testing with a halide torch
8. Why refrigeration systems require evacuation
9. Pressure/temperature requirements for dehydration
10. Use and care of vacuum pumps

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 16: (continued)

Related Information: What the Student Should Know

11. Use and care of vacuum measuring equipment
12. How to read a mercury manometer
13. Using/reading a micron gauge
14. Guidelines for evacuation
15. Characteristics of charging equipment
16. Using weight or volume to charge a system
17. Using a sight glass for charging
18. Using a superheat table for charging
19. Special conditions for liquid and vapor charging
20. Keeping charging records
21. Procedures for preparing a small refrigeration system for operation
22. Procedures for preparing a refrigeration system with a thermostatic expansion valve
23. Procedures for preparing a system with a fixed metering device

Application: What the Student Should Be Able to Do

24. Complete Service Work Order 1. (Assignment Sheet 1)
25. Complete Service Work Order 2. (Assignment Sheet 2)
26. Complete Service Work Order 3. (Assignment Sheet 3)
27. Install a line tap access valve. (Job Sheet 1)
28. Install a filter-drier on a capillary tube. (Job Sheet 2)
29. Pressurize a refrigeration system with refrigerant and dry nitrogen. (Job Sheet 3)
30. Leak check with a halide torch. (Job Sheet 4)
31. Evacuate a refrigeration system and verify level with a micron vacuum gauge. (Job Sheet 5)
32. Fill a charging cylinder. (Job Sheet 6)
33. Vapor charge a refrigeration system from a charging cylinder. (Job Sheet 7)
34. Install a thermostatic expansion valve with flare fittings. (Job Sheet 8)
35. Install a liquid indicator with flare fittings. (Job Sheet 9)
36. Install a filter-drier with flare fittings. (Job Sheet 10)
37. Pressurize a system with dry nitrogen and leak test. (Job Sheet 11)

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 16: (continued)	
	38. Triple evacuate a refrigeration system. (Job Sheet 12)
	39. Liquid charge a refrigeration system from a refrigerant cylinder. (Job Sheet 13)
	40. Check and adjust a thermostatic expansion valve using superheat parameters. (Job Sheet 14)
	41. Install a core-type access valve. (Job Sheet 15)
	42. Install a filter-drier with sweat fittings. (Job Sheet 16)
	43. Leak test a refrigeration system with an electronic leak detector. (Job Sheet 17)
	44. Evacuate a refrigeration system. (Job Sheet 18)
	45. Liquid charge using a charging cylinder. (Job Sheet 19)
	46. Vapor charge a refrigeration system form a refrigerant cylinder. (Job Sheet 20)
	47. Use suction line temperature/pressure parameters to evaluate a system charge. (Job Sheet 21)

SCANS Foundation Skills and Competencies
For *Fundamentals of Air Conditioning and Refrigeration*

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 1: Orientation			
Locate local and area companies that employ air conditioning and refrigeration technicians. (A.S. 1)	Basic Skills	Reading, writing, speaking and listening	Talks with people, interprets input, transcribes information in report form and proofs report for meaning and clarity
Unit 2: Occupational Safety			
Interpret important information from a materials safety data sheet. (A.S. 1)	Basic Skills	Reading	Comprehends information about handling, using, and storing potentially hazardous materials in the workplace
Complete a worksheet about bloodborne pathogens. (A.S. 2)	Basic Skills	Reading and writing	Comprehends written information and provides required input to complete a form
Complete a student safety pledge. (A.S. 3)	Basic Skills	Reading and writing	Comprehends written rules and attests to the understanding
Unit 3: Hand Tools			
Identify selected hand tools and describe their uses. (A.S. 1)	Basic Skills	Writing	Provides clear definition of the functions of a tool
	Thinking Skills	Problem solving	Differentiates between tools by size, shape, and functional components
Unit 4: Special Tools and Measuring			
Measure lines to the nearest quarter, eighth, and sixteenth of an inch. (A.S. 1)	Basic Skills	Arithmetic/mathematics	Performs basic linear computations based on increments of length
Read a rule. (A.S. 2)	Basic Skills	Arithmetic/mathematics	Interprets standard increments on a linear measuring device
	Thinking Skills	Problem solving	Differentiates between indicating lines of different signification
Measure selected items with slide calipers. (A.S. 3)	Basic Skills	Arithmetic/mathematics	Interprets finite increments to make critical measurements
	Thinking Skills	Problem solving	Adjusts a measuring device to define a critical distance
Grind the head of a chisel or punch. (J.S. 1)	Technology Competency	Selection	Chooses appropriate power tool for a task
		Application	Demonstrates proper procedure for tool use to sharpen a chisel or punch

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Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Sharpen a chisel or screwdriver. (J.S. 2)	Technology Competency	Selection	Chooses appropriate power tool for a task
		Application	Demonstrates proper procedure for tool use to sharpen a chisel or punch

Unit 5: Tubing and Tubing Applications

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Identify selected fittings for copper tubing. (A.S. 1)	Thinking Skills	Problem solving	Differentiates between types of fittings
		Reasoning	Applies principles of shapes and mating surfaces to identify fittings
Make a single flare with a compression-type flaring block. (J.S. 1)	Technology Competency	Application	Demonstrates proper procedure for tool use to flare tubing
Make a single flare with a Rol-Air® type flaring block. (J.S. 2)	Technology Competency	Application	Demonstrates proper procedure for tool use to flare tubing
Make a swage joint in copper tubing. (J.S. 3)	Technology Competency	Application	Demonstrates proper procedure for tool use to flare tubing
Make a 90° bend in copper tubing. (J.S. 4)	Technology Competency	Application	Demonstrates proper procedure for bending tubing to a specified degree
Make a 180° bend in copper tubing. (J.S. 5)	Technology Competency	Application	Demonstrates proper procedure for bending tubing to a specified degree
Make a 45° offset bend in copper tubing. (J.S. 6)	Technology Competency	Application	Demonstrates proper procedure for bending tubing to a specified degree

Unit 6: Iron, Plastic, and PVC Pipe

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Cut and ream PVC pipe and join it to a fitting. (J.S. 1)	Technology Competency	Application	Demonstrates proper procedure for preparing a PVC fitting for service
Cut, ream, and thread an iron pipe. (J.S. 2)	Technology Competency	Application	Demonstrates proper procedure for preparing iron pipe to receive a fitting
Join flexible pipe with a butt fusion process. (J.S. 3)	Technology Competency	Application	Demonstrates proper procedure for preparing flexible tubing for a geothermal system
Light, adjust, and shut down and air-acetylene torch. (J.S. 1)	Technology Competency	Application	Demonstrates ability to safely handle gases and related equipment to prepare a torch for ACR tubing work
Light, adjust, and shut down and air-acetylene torch with a swirl tip. (J.S. 2)	Technology Competency	Application	Demonstrates ability to safely handle gases, related equipment, and special tip to prepare a torch for ACR tubing work

SCANS Foundation Skills and Competencies

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 7: Soldering, Welding, and Brazing Equipment			
Light, adjust, and shut down an oxyacetylene welding/brazing torch. (J.S. 3)	Technology Competency	Application	Demonstrates ability to safely handle gases and related equipment to prepare a torch for ACR tubing work
Unit 8: Soft Soldering			
Use an air-acetylene torch to solder copper tubing/swage joints in upright, horizontal, and inverted positions. (J.S. 1)	Basic Skills	Science	Applies the principles of capillary action and heat distribution to solder a joint
	Technology Competency	Application	Demonstrates the ability to make physical adjustments in torch technique to solder joints in different attitudes
Use an air-acetylene torch to solder tubing/swage joints in upright, horizontal, and inverted positions. (J.S. 2)	Basic Skills	Science	Applies the principles of capillary action and heat distribution to soft solder a joint
	Technology Competency	Application	Demonstrates the ability to make physical adjustments in torch technique to solder joints in different attitudes with a different heat output
Unit 9: Silver Brazing			
Silver braze upright, inverted and horizontal swage joints. (J.S. 1)	Basic Skills	Science	Applies the principles of capillary action and heat distribution to silver solder a joint
	Technology Competency	Application	Demonstrates the ability to make physical adjustments to apply silver solder to joints in different attitudes
Silver braze a copper-to-steel joint. (J.S. 2)	Basic Skills	Science	Applies rules of heat distribution in dissimilar metals to silver solder a joint
	Technology Competency	Application	Demonstrates the ability to adapt a soldering process for use with dissimilar metals
Silver braze a copper tubing project. (J.S. 3)	Basic Skills	Science	Applies the principles of capillary action and heat distribution to complete a complex soldering project
	Technology Competency	Application	Demonstrates the ability to manipulate tubing/swage joints in different sizes to complete a complex soldering project

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 10: Aluminum Soldering, Brazing, and Epoxy Repair			
Soft solder and aluminum tubing/swage joint with an air-acetylene torch. (J.S. 1)	Basic Skills	Science	Applies the principles of capillary action and heat distribution to solder aluminum joints
	Technology Competency	Application	Demonstrates the ability to adapt a soldering process for use with aluminum tubing
Repair a hole in aluminum tubing with brazing and an air-acetylene torch. (J.S. 2)	Basic Skills	Science	Applies the principles of heat transfer to repair aluminum tubing
	Technology Competency	Application	Demonstrates the ability to work with tools and materials required for special aluminum repair
Repair a hole in aluminum with paste epoxy. (J.S. 3)	Basic Skills	Science	Mixes resin/hardener to specifications
	Technology Competency	Application	Demonstrates the ability to mix components for special tubing repair
Repair a pin-hole leak in aluminum tubing with a pre-mixed two-part epoxy stick. (J.S. 4)	Basic Skills	Science	Applies an advanced-technology adhesive
	Technology Competency	Application	Demonstrates the ability to use a pre-mixed adhesive for special tubing repair
Solder aluminum tubing to copper tubing. (J.S. 5)	Basic Skills	Science	Applies principles of heat distribution to dissimilar metals
	Technology Competency	Application	Demonstrates the ability to join dissimilar metals with a soldering process
Unit 11: Basic Mechanical Refrigeration			
Identify components of a basic mechanical refrigeration system. (A.S. 1)	Thinking Skills	Problem solving	Selects system components based on position in a system
Select component functions in a basic refrigeration cycle. (A.S. 2)	Thinking Skills	Reasoning	Identifies system components by recalling form and function
Find and identify basic refrigeration components. (J.S. 1)	Thinking Skills	Problem solving	Relates system types to probable component make-up and identifies systems for reference
Unit 12: Refrigeration System Accessories			
Identify components of a mechanical refrigeration system with accessories. (A.S. 1)	Thinking Skills	Problem solving	Selects system components based on position in system

SCANS Foundation Skills and Competencies

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 12: (continued)			
Select function for refrigeration system accessories. (A.S. 1)	Thinking Skills	Reasoning	Identifies system accessories by recalling form and function
Select operating positions for service valves	Thinking Skills	Reasoning	Relates valve function to dynamics of system
Find and identify refrigeration system accessories. (J.S. 1)	Thinking Skills	Problem solving	Relates type of accessories to position, form, and function in a system
Unit 13: EPA Requirements for Refrigeration Management and Technician Certification			
Answer sample certification test questions. (A.S. 1)	Thinking Skills	Problem solving	Recognizes problems based on a knowledge of system components and system operating dynamics
		Reasoning	Applies principles of mechanical refrigeration to solve typical system operations or system problems
Unit 14: Refrigerants, Desiccants, and Lubricants Old and New			
Compute temperature/pressure relationships. (A.S. 1)	Basic Skills	Arithmetic/mathematics	Applies mathematical formulas to determine system conditions
Attach a manifold gauge set to service ports. (J.S. 1)	Technology Competency	Application	Sets up gauges to properly measure system pressures
Pressure check a domestic refrigeration system. (J.S. 2)	Technology Competency	Application	Sets up manifold gauge set to properly measure operating pressures in a small refrigeration system
Pressure check a residential air conditioning system. (J.S. 3)	Technology Competency	Application	Sets up manifold gauge set to properly measure operating pressures in an air conditioning system
Pressure check a commercial refrigeration system. (J.S. 4)	Technology Competency	Application	Sets up manifold gauge set to properly measure operating pressures in a large refrigeration system.
Unit 15: Refrigerant Recovery, Recycling, and Reclaiming			
Use a hand-operated pump to recover refrigerant from a small AC or refrigeration system. (J.S. 1)	Technology Competency	Application	Recovers refrigerant with proper equipment and process to comply with EPA regulations
Use a recovery machine to recover refrigerant from an AC or refrigeration system. (J.S. 2)	Technology Competency	Application	Recovers refrigerant with proper equipment and process to comply with EPA regulations

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Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 15: (continued)			
Use a recovery/recycling machine to recover/recycle refrigerant from an AC or refrigeration system	Technology Competency	Application	Recovers and recycles refrigerant with proper equipment and process to comply with EPA regulations and guidelines for filtering refrigerant
Unit 16: Evacuating, Pressurizing, Leak Testing, and Charging			
Complete Service Work Order 1. (A.S. 1)	Basic Skills	Writing	Communicates service information by completing a form
Complete Service Work Order 2. (A.S. 2)	Basic Skills	Writing	Communicates service information by completing a form
Complete Service Work Order 3. (A.S. 3)	Basic Skills	Writing	Communicates service information by completing a form
Install a line tap access valve. (J.S. 1)	Technology Competency	Application	Demonstrates proper use of tools and components to prepare a service access
Install a filter-drier on a capillary tube. (J.S. 2)	Technology Competency	Application	Demonstrates proper use of tools and components to install a filtering device
Pressurize a refrigeration system with refrigerant and dry nitrogen. (J.S. 3)	Technology Competency	Application	Demonstrates proper use of tools and components to prepare a system for leak testing
	Basic Skills	Science	Regulates pressure by referencing a gauge
Leak check with a halide torch. (J.S. 4)	Technology Competency	Application	Demonstrates ability to light, adjust, and operate a torch to check system integrity
	Basic Skills	Science	Monitors copper element to detect color changes that indicate the presence of R-22
Evacuate a refrigeration system and verify level with a micron vacuum gauge. (J.S. 5)	Technology Competency	Application	Demonstrates the ability to properly use a vacuum pump and a vacuum measuring gauge
	Basic Skills	Science	Verifies evacuation level with a digital device
Fill a charging cylinder. (J.S. 6)	Technology Competency	Application	Demonstrates the ability to safely transfer refrigerant from a refrigerant cylinder to a graduated charging device
Vapor charge a refrigeration system from a charging cylinder. (J.S. 7)	Technology Competency	Application	Demonstrates the ability to safely charge a system from a graduated cylinder
	Basic Skills	Arithmetic/mathematics	Determines proper charge by relating quantity to mathematical chart

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SCANS Foundation Skills and Competencies

Unit 16: (continued)

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Install a thermostatic expansion valve with flare fitting. (J.S. 8)	Technology Competency	Application	Demonstrates the ability to install a metering device with mechanical fittings
	Basic Skills	Science	Selects application points related to components and direction of refrigerant flow
Install a liquid indicator with flare fittings. (J.S. 9)	Technology Competency	Application	Demonstrates the ability to install a refrigerant monitoring device
	Basic Skills	Science	Selects application point related to system components
Install a filter-drier with flare fitting. (J.S. 10)	Technology Competency	Application	Demonstrates the ability to install a filtering device with mechanical fittings
	Basic Skills	Science	Selects optimum point in system for filtering device to function best
Pressurize a system with dry nitrogen and leak test. (J.S. 11)	Technology Competency	Application	Demonstrates the ability to prepare a system for leak testing with leak testing fluid
	Basic Skills	Science	Regulates pressure from a cylinder by referencing a gauge
Triple evacuate a refrigeration system. (J.S. 12)	Technology Competency	Application	Demonstrates the ability to set up and operate a vacuum pump
	Basic Skills	Science	Monitors vacuum level with a gauge
Liquid charge a refrigeration system from a refrigerant cylinder. (J.S. 13)	Technology Competency	Application	Demonstrates the ability to safely liquid charge from a basic refrigerant storage facility
Check and adjust a thermostatic expansion valve using superheat parameters. (J.S. 14)	Technology Competency	Application	Demonstrates the ability to evaluate system performance
	Basic Skills	Science	Uses temperature readings from system to equate system performance with a norm
Install a core-type access valve. (J.S. 15)	Technology Competency	Application	Demonstrates the ability to install a service valve with a safety feature
Install a filter-drier with sweat fittings. (J.S. 16)	Technology Competency	Application	Demonstrates the ability to install a filtering device with a brazing process
Leak test a refrigeration system with an electronic leak detector. (J.S. 17)	Technology Competency	Application	Demonstrates the ability to verify integrity of a system with a minimal R-22 charge

Task	Skill Group Competency Group	Sub Skill Sub Competency	Description
Unit 16: (continued)			
Evacuate a refrigeration system. (J.S. 18)	Technology Competency	Application	Demonstrates the ability to prepare a system for pressurizing
Liquid charge using a charging cylinder. (J.S. 19)	Technology Competency	Application	Demonstrates the ability to charge by volume
	Basic Skills	Arithmetic/mathematics	Interpolates scale readings to determine amount of charge
Vapor charge a refrigeration system from a refrigerant cylinder. (J.S. 20)	Technology Competency	Application	Demonstrates the ability to safely vapor charge from a basic refrigerant storage device
	Basic Skills	Arithmetic/mathematics	Monitors refrigerant weight to determine accurate charge
Use suction line temperature/pressure parameters to evaluate a system charge. (J.S. 21)	Technology Competency	Application	Demonstrates the ability to evaluate system operating performance
	Basic Skills	Science	Interpolates from system temperature/pressure readings to equate system performance to a norm

Fundamentals of Air Conditioning and Refrigeration

Tools, Materials, and Equipment List

Basic Hand Tools

Screwdriver assortment
Plier assortment
Hammer assortment
Refrigeration ratchet
Hacksaw w/extra blades
Open-end, adjustable, and Allen wrenches
Pipe bender and pipe bending spring

Basic Bench/Power Tools

Vise
Drill press
Grinder

Line Service Tools and Materials

Assorted tubing, copper, aluminum, steel, PVC, flexible
Fittings for assorted tubing
Soldering/brazing flux
PVC solvent
Epoxy
Stainless steel wire brush
Tube fitting brush
Sand cloth
Filler metal rods
Soft and silver solder
Pipe threading dies and ratchet
Oil can
Pipe cutting tool
Pipe reamer
Tubing cutting tool/reamer
Black iron and galvanized pipe
Swaging tool
Flaring tool

System Service Equipment

Charging cylinder
Recovery machine
Recovery/recycling machine
Filters/Filter-driers
Two-stage vacuum pump
Single-stage vacuum pump

System Service Tools

Manifold gauge set w/pressure/temperature chart(s)
Mercury manometer
Micron gauge
Electronic leak tester
Halide leak detector
Leak detecting fluid
Thermometer
Remote sensing thermometer

Torches and Related Equipment

Air-acetylene torch and hoses
Oxyacetylene torch and hoses
Assorted soldering/brazing tips including swirl tips
Acetylene/oxygen cylinders
Hand-held torch
Small propane/butane/other small gas cylinders

Refrigerants and Gases

Refrigerants as required for selected systems
R-22 for leak testing and service
Dry nitrogen
CO_2

Service Literature

Manufacturer's specifications for selected systems
Appropriate OSHA references for work place hazards and bloodborne pathogens
Material Safety Data Sheets for refrigerants, gases, and any other hazardous substances in the workplace

Fundamentals of Air Conditioning and Refrigeration

Tools, Materials, and Equipment List

Suggested Student Tool Kit

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Adjustable wrench (8″ or 10″)
Allen wrench set
Arc-joint pliers (8″ or 10″)
Ball peen hammer
Clamp-on ampmeter
Crimping tool
Diagonal pliers
Drive socket set with extension (¼″)
Drive socket set with extension (⅜″)
Electrical tape
Electrical wire nuts
Electrical wire terminals
Electricians knife
Flaring kit
Flat-tip screwdrivers (assortment of four sizes)
Gauge manifold set with quick connect hose
Hacksaw/extra blades
Locking pliers (6″)
Longnose pliers (6″)
Measuring tape (12′)
Mercury thermometer
Nutdrivers (set of seven)
Phillips-head screwdrivers (assortment of four sizes)
Pocket thermometer
Rule (12″)
Safety glasses
Slipjoint pliers (6″)
Soldering iron
Swaging kit
Toolbox with lock and nametag
Torch striker
VOM/analog-digital meter
Wirecutters (6″)

The VICA Student Tool Kit contains some items not specifically employed in *Fundamentals of Air Conditioning and Equipment*. However, the complete kit is essential for students who advance to other texts in the MAVCC ACR series.

Fundamentals of Air Conditioning and Refrigeration

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Valves and Accessories for Refrigeration and Air Conditioning Applications. Catalog 111C. Melrose Park, IL: The Henry Valve Company, 1994.

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ACR Orientation
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to locate local and area companies that employ air conditioning and refrigeration technicians. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to ACR orientation with their correct definitions.
2. Match ACR manufacturing jobs with their training requirements.
3. Match ACR wholesaling jobs with their training requirements.
4. Match ACR service and installation jobs with their training requirements.
5. Select true statements about ACR building maintenance jobs and their training requirements.
6. Complete statements about future opportunities for ACR technicians.
7. Locate local and area companies that employ air conditioning and refrigeration technicians. (Assignment Sheet 1)

ACR Orientation
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add graphic materials or overhead transparencies as needed.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss the assignment sheet. Review criteria for evaluation of the activity.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.
14. Compile assignment sheet rating and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.
15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Find an air conditioning firm in your area that specializes in retrofitting. Ask the owner or manager of the firm to talk to the class about the importance of the retrofit market and what it means in relation to jobs for ACR mechanics. Skill areas: **Communication skills, listening.**

2. Have copies of state or local laws that reflect compliance with new EPA requirements for evacuating and recycling refrigerants. Impress upon students the importance of adhering to the laws as they become involved in AC service. Encourage students to become certified in refrigerant management as early in their careers as they can. Certification opens doors to better jobs. Skill areas: **Communication skills, listening.**

3. Alert appropriate people at firms in your area that students will be contacting them for information to help them complete Assignment Sheet 1 This is a courtesy that busy companies appreciate. Have a name for students to contact when they make their phone call or personal visit. Assign two or three students to work together. Skill areas: **Group effectiveness skills, teamwork.**

4. Invite a former student or several former students to talk to the class about ACR work in general. Chances are, some of the students will have some real war stories to tell, so use the opportunity to talk about Teacher Supplement 1. Have the class form groups to find the oldest air conditioning system in town, or the most unusual system in town. Have the groups report their findings to the class. Skill areas: **Group effectiveness skills, teamwork.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1993.

3. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Resources

Suggested Supplemental Resources

1. Coastal Video of Virginia is in the process of completing an entire series of videos dedicated to air conditioning and refrigeration. The videos will stress basics with color graphics of the basic refrigeration cycle and variations of its applications. Various tapes in the video series will be dedicated to ACR installation, troubleshooting, and maintenance with the accent on safety. Special emphasis will be placed on new EPA rules for refrigerants in the ACR workplace. For a free catalog of Coastal Video products, call 1-800-767-7703, or write:

   Coastal Video Communications Corp.
   3083 Brickhouse Court
   Virginia Beach, VA 23452

2. TPC Training Systems offers two video training programs, one titled *Basic Air Conditioning*, and a complementary program titled *Working Safely With Electricity*. For information, call TPC at 1-800-837-8872 or write:

   TPC Training Systems
   750 Lake Cook Rd.
   Buffalo Grove, IL 60089

3. Manufacturers of air conditioning systems all have materials designed for training technicians in all phases of the industry, from proper installation to troubleshooting and repair. Check with local ACR companies for available catalogs, owner's manuals, and other materials that could assist students in learning more about the industry in general and specific types of equipment and trade practices.

ACR Orientation
Unit 1

Answers to Assignment Sheet 1

Assignment Sheet 1—Evaluate according to criteria presented in the assignment sheet.

ACR Orientation
Unit 1

Answers to Written Test

1.	a.	9	f.	1	k.	2
	b.	4	g.	6	l.	11
	c.	10	h.	7	m.	8
	d.	5	i.	13	n.	3
	e.	12	j.	14	o.	15

2.	a.	2	d.	1
	b.	3	e.	4
	c.	6	f.	5

3.	a.	3
	b.	5
	c.	2
	d.	1
	e.	4

4.	a.	2	e.	5
	b.	1	f.	6
	c.	3	g.	4
	d.	7		

5. b

6.	a.	three quarters of a million
	b.	gradual
	c.	Recovery and recharging
	d.	building maintenance
	e.	retrofit
	f.	a variety of skills

ACR Orientation
Unit 1

Written Test

Name ______________________ Date ______________ Score ______

1. Match the terms on the right with their correct descriptions.

______a. The conditioning of air to include the control of temperature/humidity, quality, and distribution

______b. A professional who evaluates and recommends improvements for existing air conditioning systems, or one who designs new energy-efficient air conditioning systems

______c. A professional that recommends equipment and estimates the cost of retrofitting and existing air conditioning system or installing a new system

______d. A mechanic trained especially to install air conditioning equipment

______e. A person who serves as a liaison between a manufacturer and retailer or wholesaler

______f. A person trained to troubleshoot and repair air conditioning problems or to help with maintenance or installation of systems

______g. An individual or company that sells, designs, installs, and services both commercial and residential air conditioning systems

______h. A company that makes a particular brand of air conditioning systems or components

______i. A dealer who sells and services air conditioning equipment to the general public

1. Mechanic
2. Sales associate
3. Wholesaler
4. Energy consultant
5. Installer
6. Mechanical contractor
7. O.E.M.
8. Service technicians
9. Air conditioning
10. Estimator
11. Service representative
12. Manufacturer's representative
13. Retailer
14. Retrofit
15. Refrigeration

Written Test

______j. To repair or remodel an existing ACR system for the purpose of adding energy-efficient components or installing a better-performing total system

______k. A person who sells air conditioning systems and service contracts

______l. A professional employed by a manufacturer to assist retailers with everything from sales promotions to the installation and service of a company's products

______m. Mechanics trained to maintain and repair equipment and systems sold by a retailer

______n. A company or individual who stocks air conditioning equipment in quantities large enough to serve the needs of retailers in a large region

______o. The mechanical compression of a refrigerant in a closed system in order to remove heat and produce and maintain conditions that will chill or freeze food in a domestic or commercial appliance.

2. Match ACR manufacturing jobs with their training requirements. Place the number beside the training requirement in the blank beside the job description.

______a. Must have at least a high school education and a mechanical background

______b. Must have at least a high school education and have a math background good enough to handle basic adding and subtracting

______c. Must have a minimum high school education with some sales experience; some college is preferred, but the accent in this job is on personality and the ability to talk with people

1. Service representative
2. Assembler
3. Shipping clerk
4. Designer
5. Engineer
6. Manufacturer's representative

Written Test

______d. Must have a minimum high school education plus technical school training and experience in all phases of cooling, heating, and refrigeration; an outgoing personality is certainly an asset

______e. Usually requires an associate or four-year degree in mechanical design

______f. Should have a four-year degree in mechanical or electrical engineering, or both

3. Match ACR wholesaling jobs with their training requirements.

______a. Should have a high school education with some bookkeeping experience

______b. Should have technical school training with emphasis on drafting and math

______c. Should have a high school education with some technical school training and some bookkeeping experience

______d. Should have a high school education plus technical school training along with business training; personality is an asset in this job

______e. Should have a high school education, be good at following directions, and have a safe driving record

1. Sales person
2. Counter person
3. Shipping clerk
4. Expediter
5. Estimator

4. Match ACR service and installation jobs with their training requirements. Place the number beside the training requirement in the blank beside the job description.

______a. Should have technical school training or apprenticeship training in sheet metal, wiring, and piping, with experience in all three areas

______b. Should have technical school training and field experience in working with a variety of cooling systems

1. Cooling mechanic
2. Installer
3. Heating mechanic
4. Energy consultant

Written Test

______c. Should have technical school training and field experience in working with a variety of heating systems

______d. Should have technical school training and field experience in working with a variety of refrigeration systems

______e. Should have technical school training and extensive field experience with a variety of cooling, heating, and refrigeration systems

______f. Should have technical school training backed up with extensive field experience, and appropriate business training

______g. Should have technical or college training in system applications, business, and environmental matters

5. Service manager

6. Mechanical contractor

7. Refrigeration mechanic

5. Select true statements about ACR building maintenance jobs and their training requirements. Place an "X" beside each true statement.

______a. **Cooling and heating mechanics** — Must have technical school or apprenticeship training, but service experience is not a beginning requirement

______b. **Supervisor** — Must have technical school training or apprenticeship and extensive experience in servicing industrial heating/cooling equipment and the electrical and piping skills required for much of the work

6. Complete statements about future opportunities for ACR mechanics. Circle the material that best completes each of the following statements.

a. In the mid-1980s, there were more than (**three quarters of a million**) (**two million**) ACR mechanics working in the United States, and that number has been increasing and will continue to increase well into the 21st Century.

b. The increase in employment will not be as fast as it has been in the past, but the (**very slow**) (**gradual**) increase will bring with it some areas where technicians can specialize, and that should mean better paying jobs.

c. The biggest area of specialization will be in the general handling of refrigerants in the process of (**recovery and recharging**) (**recharging**); the Environmental Protection Agency has strict new guidelines for those processes.

Written Test

d. Technicians who become certified to recover and recharge, or recover and recycle refrigerants will be in demand, not just for working in ACR installation and service companies, but in (**building maintenance**) (**general industry**) jobs.

e. A generally increasing interest in energy management nationwide should contribute to an increase in (**new construction**) (**retrofit**) work and add to the optimistic employment outlook for ACR technicians in future years.

f. Advances in control technology, compressor technology, and other areas of the ACR industry will demand technicians with (**a variety of skills**) (**a single skill**), and technicians who have a good technical background in a variety of applications will have the best jobs.

***Permission to duplicate this test is granted.**

ACR Orientation
Unit 1

Teacher Supplement 1—Important Dates in Refrigeration and Air Conditioning History

Jacob Perkins patented the first refrigeration machine in America in 1834. The machine was a closed compression system that did work, but failed to become a commercial success. The technology to refrigerate foods took years to evolve, and the Kelvinator company sold the first domestic refrigerator in American markets in 1918.

In 1930, refrigerant R-12 was developed and became the most popular of the fluorocarbon refrigerants, but after many years of use, refrigerant R-12 was outlawed by the Environmental Protection Agency in 1992. R-12 will be phased out gradually with strict laws governing recovery and recharging of systems. In the meantime, there are literally dozens of new refrigerants in the race to replace R-12 with a safe product.

In air conditioning, the Carrier Air Conditioning Company was formed in 1908, and the founder, Willis H. Carrier is considered the outstanding pioneer of refrigerated air conditioning, and is referred to as the "father of air conditioning." But it was not until 1934 that Frigidaire air conditioned an entire house, and a year later, 1935, General Electric installed the first heat pump system in America.

ACR Orientation
Unit 1

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Locate Local and Area Companies That Employ Air Conditioning and Refrigeration Technicians Rating _____

Comments: ____

____

Other ____

____

Written Tests: Pretest _____ Posttest _____

Total _____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

*Permission to duplicate this form is granted.

ACR Orientation
Unit 1

Information Sheet

1. **Terms and definitions**

   a. **Air conditioning** — The conditioning of air to include the control of temperature/humidity, quality, and distribution

   b. **Energy consultant** — A professional who evaluates and recommends improvements for existing air conditioning systems, or one who designs new energy-efficient air conditioning systems

   c. **Estimator** — A professional that recommends equipment and estimates the cost of retrofitting and existing air conditioning system or installing a new system

   d. **Installer** — A mechanic trained especially to install air conditioning equipment

   e. **Manufacturer's representative** — A person who serves as a liaison between a manufacturer and retailer or wholesaler

   f. **Mechanic** — A person trained to troubleshoot and repair air conditioning problems or to help with maintenance or installation of systems

   g. **Mechanical contractor** — An individual or company that sells, designs, installs, and services both commercial and residential air conditioning systems

   h. **O.E.M. (original equipment manufacturer)** — A company that makes a particular brand of air conditioning systems or components

   i. **Refrigeration** — The mechanical compression of a refrigerant in a closed system in order to remove heat and produce and maintain conditions that will chill or freeze food in a domestic or commercial appliance

   j. **Retailer** — A dealer who sells and services air conditioning equipment to the general public

   k. **Retrofit** — To repair or remodel an existing ACR system for the purpose of adding energy-efficient components or installing a better-performing total system

   l. **Sales associate** — A person who sells air conditioning systems and service contracts

   m. **Service representative** — A professional employed by a manufacturer to assist retailers with everything from sales promotions to the installation and service of a company's products

Information Sheet

   n. **Service technicians** — Mechanics trained to maintain and repair equipment and systems sold by a retailer

   o. **Wholesaler**— A company or individual who stocks air conditioning equipment in quantities large enough to serve the needs of retailers in a large region

2. **ACR manufacturing jobs and their training requirements**

   a. **Assembler** — Must have at least a high school education and a mechanical background

   b. **Shipping clerk** — Must have at least a high school education and have a math background good enough to handle basic adding and subtracting

   c. **Manufacturer's representative** — Must have a minimum high school education with some sales experience; some college is preferred, but the accent in this job is on personality and the ability to talk with people

   d. **Service representative** — Must have a minimum high school education plus technical school training and experience in all phases of cooling, heating, and refrigeration; an outgoing personality is certainly an asset

   e. **Designer** — Usually requires an associate or four-year degree in mechanical design

   f. **Engineer** — Should have a four-year degree in mechanical or electrical engineering, or both

3. **ACR wholesaling jobs and their training requirements**

   a. **Shipping clerk** — Should have a high school education with some bookkeeping experience

   b. **Estimator** — Should have technical school training with emphasis on drafting and math

   c. **Counter person** — Should have a high school education with some technical school training and some bookkeeping experience

   d. **Sales person** — Should have a high school education plus technical school training along with business training; personality is an asset in this job

   e. **Expediter** — Should have a high school education, be good at following directions, and have a safe driving record

Information Sheet

4. **ACR service and installation jobs and their training requirements**

   a. **Installer** — Should have technical school training or apprenticeship training in sheet metal, wiring, and piping, with experience in all three areas

   b. **Cooling mechanic** — Should have technical school training and field experience in working with a variety of cooling systems

   c. **Heating mechanic** — Should have technical school training and field experience in working with a variety of heating systems

   d. **Refrigeration mechanic** — Should have technical school training and field experience in working with a variety of refrigeration systems

   e. **Service manager** — Should have technical school training and extensive field experience with a variety of cooling, heating, and refrigeration systems

   f. **Mechanical contractor** — Should have technical school training backed up with extensive field experience, and appropriate business training

   g. **Energy consultant** — Should have technical or college training in system applications, business, and environmental matters

5. **ACR building maintenance jobs and their training requirements**

   a. **Cooling and heating mechanics** — Must have technical school or apprenticeship training and service experience

   b. **Supervisor** — Must have technical school training or apprenticeship and extensive experience in servicing industrial heating/cooling equipment and the electrical and piping skills required for much of the work

6. **Future opportunities for ACR mechanics**

   a. In the mid-1980s, there were more than three quarters of a million ACR mechanics working in the United States, and that number has been increasing and will continue to increase well into the 21st Century.

   b. The increase in employment will not be as fast as it has been in the past, but the gradual increase will bring with it some areas where technicians can specialize, and that should mean better paying jobs.

   c. The biggest area of specialization will be in the general handling of refrigerants in the process of recovery and recharging; the Environmental Protection Agency has strict new guidelines for those processes.

Information Sheet

d. Technicians who become certified to recover and recharge, or recover and recycle refrigerants will be in demand, not just for working in ACR installation and service companies, but in building maintenance jobs.

e. A generally increasing interest in energy management nationwide should contribute to an increase in retrofit work and add to the optimistic employment outlook for ACR technicians in future years.

f. Advances in control technology, compressor technology, and other areas of the ACR industry will demand technicians with a variety of skills, and technicians who have a good technical background in a variety of applications will have the best jobs.

ACR Orientation
Unit 1

Assignment Sheet 1—Locate Local or Area Companies That Employ Air Conditioning and Refrigeration Technicians

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of companies found	_____
Contact or reference properly given	_____
Products or services identified	_____
Employee numbers stated	_____

Directions: Use the local phone directory to find companies in your area who work in the ACR industry as manufacturers, wholesalers, or retailers. Call at least one company in each part of the business and speak with someone who can tell you the general activity of the business and how many ACR technicians or other personnel the company employs. Be sure to identify yourself when you call and explain why you are seeking the information. Then try to find a company that hires ACR personnel for building maintenance and list the variety of skills such people must have. Enter your findings as follows:

a. Manufacturing firm contacted: ______________________________

Name of contact and date: ______________________________

Product(s) manufactured: ______________________________

Number of employees: ______________________________

b. Wholesaling firm contacted: ______________________________

Name of contact and date: ______________________________

Number of products handled: ______________________________

Number of employees: ______________________________

Assignment Sheet 1

c. Retailing firm contacted: ______________________________

Name of contact and date: ______________________________

Major area of business: ______________________________

Number of employees: ______________________________

d. Firm contacted for building maintenance: ______________________________

Name of contact and date: ______________________________

Special training requirements for personnel: ______________________________

____

Number of employees: ______________________________

Occupational Safety
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify workplace hazards and complete a worksheet on material safety data sheets. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to occupational safety with their correct definitions.
2. Select true statements about guidelines for personal lab safety.
3. Complete statements about guidelines for general shop safety.
4. Complete statements about guidelines for machine safety.
5. Select true statements about guidelines for solvent safety.
6. Complete statements about guidelines for workplace electrical safety.
7. Solve problems about characteristics of a clean and orderly shop.
8. Select true statements about the fire triangle.
9. Match classes of fires with ways to put them out.
10. Solve problems about procedures for safe lifting.
11. Select true statements about guidelines for handling an accident.
12. Select true statements about circuit amperages and their affects on the human body.

Objective Sheet

13. Select true statements about guidelines for general electrical safety.

14. Complete statements about guidelines for using electrical tools.

15. Match safety colors with their applications.

16. Match accident prevention signs with their applications and colors.

17. Match accident prevention tags with their applications and color schemes.

18. Complete statements about what you should know about OSHA's *Hazard Communication Standard.*

19. Select true statements about ways to protect yourself from hazardous substances in the workplace.

20. Select true statements about what you should know about OSHA's *Bloodborne Pathogen Standard.*

21. Select true statements about other items related to the *Bloodborne Pathogen Standard.*

22. Interpret important information from a materials safety data sheet. (Assignment Sheet 1)

23. Complete a worksheet about bloodborne pathogens. (Assignment Sheet 2)

24. Complete a student safety pledge. (Assignment Sheet 3)

Occupational Safety
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make a transparency from the transparency master included with this unit. It appears in the teacher edition only and is designed to be used with the following objective:

   TM 1—Material Safety Data Sheet (Objective 12)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the assignment sheets. Review criteria for evaluation of these activities.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

14. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. At some point in this unit, invite a trained professional to talk to the class about personal hygiene and its importance not only in the workplace, but at home. Try to work this in with Objective 2, and use the occasion to show students the location of the first aid kit, eye-wash stations, showers, and fire extinguishers. Skill areas: **Foundation skills, listening.**

2. For Objective 8 and 9, arrange for a member of the local fire department to talk to the class about how to use a fire extinguisher. Review the types of fires that could happen in your lab or classroom. Point out fire exits and outside reassembly points. If you live in an area where severe weather alerts are common, talk to the class about exit procedures and where to reassemble. Have students work in groups to examine the fire extinguishers in the lab area. Have the groups report on the extinguishers by type and tell when each extinguisher was last serviced or checked. Skill areas: **Group effectiveness skills, teamwork.**

3. Read objective 11 carefully, and add to it safety directives from your school. If emergency procedures of the school are different from those listed in the objective, change the objective and questions on the written test. Skill areas: **Foundation skills, reading and listening.**

4. Spend appropriate time on Objective 18 and 19. Have MSDSs available for the students to examine. Talk about the chemicals, solvents, and any hazardous substances students may encounter in the lab or classroom. This is an important objective because it concerns important safety changes that are happening in the workplace. Skill areas: **Foundation skills, reading and listening.**

5. Be sure to have appropriate materials ready when you discuss Objective 20, 21, and 22. The *Bloodborne Pathogen Standard* is equally important to schools as it is to the workplace. Coordinate with the school safety officer or school nurse to present these objectives properly. Have a proper first aid kit to show students. Skill areas: **Learning skills, learning to learn.**

Resources Used In Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1993.

Suggested Activities

Suggested Supplemental Resources

1. *OSHA's General Industry Standards (29CFR Part 1910)*, and the *NIOSH Pocket Guide to Chemical Hazards* are both available from:

   Superintendent of Documents
   U.S. Government Printing Office
   Washington, DC 20402

2. The *1993 Catalog of Products and Services* is available from the Air Conditioning Contractors of America. The free catalog is one of the most extensive ever published by ACCA, and especially important because it has several items relating to OSHA's *Hazard Communication Standard*, and other materials related to refrigerant recovery, certification procedures, and general information about the new EPA refrigerant standards. There are several other items in the manual that all ACR programs will want to order. For the free manual, call ACCA at 202-483-9370 or FAX them at 202-234-4721, or write:

   ACCA
   1513 15th Street, N.W.
   Washington, DC 20036

3. A "Compliance Safety System" for OSHA's *Bloodborne Pathogens Standard* is available from Summit Training Source, Inc. The program includes facilitator and student workbooks and a well-produced video. Call toll free, 800-842-0466, or write to:

   Summit Training Sources, Inc.
   620 Three Mile Road, N.W.
   Grand Rapids, MI 49504

4. *Hazard Communication: A Compliance Kit for the Construction Industry* is available from ACCA. Although it is listed on page 23 of the catalog mentioned in item 1, this specific program merits special attention because of the quality of the program, but also because part of the program includes a training log to record and verify employee video training session. For information about pricing, call or write ACCA as directed in item 1 of this list.

5. For information about the Hi-Jack ACR dolly/lifter referenced in Objective 10, write:

   Vermette Machine Company, Inc.
   No. 7 - 143rd Street
   Hammond, IN 40327-1395

   Or call the Vermette Company at 1-800-348-6454

Occupational Safety
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1

a. NABC PLUS IV
b. Spartan Chemical Company, Inc.
c. 419-531-5551
d. Blue viscous liquid, floral odor
e. Completely
f. None
g. None are known
h. Skin
i. Drink large quantities of water
j. Immediately flush with water for 15 minutes. If irritation persists, see a doctor.
k. Small amounts may be flushed with large amounts of water into a sanitary sewer. Larger quantities should be picked up with absorbent material and disposed of in accordance with Federal, state, or local regulations.
l. Good general ventilation and local ventilation may be necessary for some operations.
m. Acid resistant gloves and safety glasses for handling; no special storage requirements.

Assignment Sheet 2

a. (2)
b. (1)
c. (2)
d. (2)

Assignment Sheet 3—Evaluate according to criteria presented in the assignment sheet.

Occupational Safety
Unit 2

Answers to Written Test

1. a. 3
   b. 5
   c. 6
   d. 8
   e. 1
   f. 4
   g. 2
   h. 7

2. b, c, e

3. a. defective
   b. been instructed how to use
   c. hazardous
   d. liquids
   e. safety
   f. material safety data sheets

4. a. starting
   b. brush
   c. Disconnect power from
   d. running
   e. "Out of Order"

5. b, d, e

6. a. frayed
   b. before
   c. an extension cord
   d. not properly grounded

7. a. (3)
   b. (2)

8. a

9. a. 2
   b. 5
   c. 1
   d. 3
   e. 4

10. a. (3)
    b. (2)
    c. (1)

11. c, d, e

Answers to Written Test

12. b, c, d, e, f

13. a, b, c, d, g, h, i

14. e, f, g, h, i

15. a. 4
    b. 6
    c. 1
    d. 3
    e. 7
    f. 2
    g. 5

16. a. 2
    b. 1
    c. 3

17. a. 2
    b. 4
    c. 1
    d. 3

18. a. substances
    b. on file in the workplace
    c. chemical hygiene plan
    d. mouth
    e. corrosive
    f. law

19. b, d

20. b, c, d

21. a, c, e

Occupational Safety
Unit 2

Written Test

Name ______________________________ Date ______________ Score ____

1. Match the terms on the right with their correct descriptions.

_____a. Any suddenly occurring, unintentional event which causes injury or damages property

_____b. An OSHA regulation designed to protect employees from the dangers of AIDS and other bloodborne diseases that may result from a blood-producing accident in the workplace

_____c. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____d. An OSHA regulation designed to protect employees from the dangers of chemicals and other hazardous substances in the workplace

_____e. A written reference of any chemical used in a workplace, its potential for causing bodily harm, and an accompanying first aid guide; these are required by OSHA's *Hazard Communication Standard*

_____f. Federal legislation designed to insure safe and sanitary working conditions for all employees; the act is administered and enforced by the Occupational Safety and Health Administration

_____g. A bacterium or virus that causes disease

_____h. The state or condition of being safe from danger, risk, or injury

1. MSDS
2. Pathogen
3. Accident
4. OSHA
5. *Bloodborne Pathogen Standard*
6. First aid
7. Safety
8. *Hazard Communication Standard*

Written Test

2. Select true statements about guidelines for personal lab safety. Place an "X" beside each true statement.

    ______a. Wear safety glasses when you need them, and use the proper helmet or goggles when welding or brazing.

    ______b. Confine long hair and loose clothing before operating rotating equipment.

    ______c. Remove all metal jewelry before working in the shop.

    ______d. Use soap and water infrequently; soap can cause skin irritations.

    ______e. Be safety conscious at all times, avoid all horseplay, and conduct yourself in a manner conducive to shop safety at all times.

3. Complete statements about guidelines for general shop safety. Circle the material that best completes each of the following statements.

    a. Keep all hand tools sharp, clean, and in safe working condition, and report (**defective**) (**missing**) tools or machines to your instructor.

    b. Never operate potentially hazardous machines until you have (**been instructed how to use**) (**actually practiced with**) the machine and have your instructor's permission to use the machine.

    c. In addition to wearing safety glasses, wear goggles, gloves, shoes, and aprons, or other appropriate clothing when working with (**flammable**) (**hazardous**) materials or equipment.

    d. Keep the lab floor clean of scraps and litter, and report spilled (**liquids**) (**solvents**) immediately so they can be properly removed.

    e. Even if you mean to just play around, never throw an object for any reason, consider the (**needs**) (**safety**) of your co-workers, and remember that horseplay is strictly outlawed in a class or lab.

    f. Read the (**labels**) (**material safety data sheets**) for every chemical or hazardous material that you have to work with and know what first aid procedures to follow if the chemical is misused or accidentally spilled.

Written Test

4. Complete statements about guidelines for machine safety. Circle the material that best completes each of the following statements.

    a. Make sure all guards and barriers are in place before (**staring**) (**oiling**) a machine.

    b. Clean chips from a machine only with a (**brush**) (**knife**), not with a towel, your bare hands, or with compressed air.

    c. (**Disconnect power from**) (**Turn the switch off on**) the machine before oiling or cleaning or any other maintenance work.

    d. Never leave a (**defective**) (**running**) machine unattended even for a second, and turn off the power before leaving a machine.

    e. If a machine exhibits dangerous performance, stop immediately, disconnect the power, and tag the machine with a "Do Not Start" or (**"Out of Order"**) (**"Defective"**) tag and report the bad equipment to your instructor.

5. Select true statements about guidelines for solvent safety. Place an "X" beside each true statement.

    ______a. Use a solvent only after putting on gloves and a face shield.

    ______b. Clean up spilled solvent immediately, if you can safely do so, and report the accident to your instructor.

    ______c. Use solvents only in outside areas, and avoid letting solvent vapors get on your skin or in your eyes.

    ______d. If your hands, arms, or other body parts are exposed to solvents, wash with soap and water as soon as possible, and be sure to wash well.

    ______e. Store towels used for solvents or towels with oily waste in approved metal containers.

6. Complete statements about guidelines for workplace electrical safety. Circle the material that best completes each of the following statements.

    a. Do not work with (**household**) (**frayed**) electrical cords of any kind; repair or replace cords as needed.

    b. Avoid dragging extension or drop cords through dirt or oil, and if cords are accidentally dirtied, clean them (**immediately after**) (**before**) using them.

    c. Never run over (**an extension cord**) (**covered cables**) or a drop cord with a dolly or service cart.

    d. Never, never cut off the grounding prong on an electrical plug, and avoid using outlets that are (**too far from your work**) (**not properly grounded**).

Written Test

7. Solve problems about characteristics of a clean and orderly shop. Circle the number beside the statement that best solves each of the following problems.

   a. You and coworkers have been asked to examine an air conditioning shop to see if it is neat and orderly. The group is having trouble getting started. To solve the problem, you should:

      (1) Make sure all access areas are lined with red paint.

      (2) Check the electrical service entrance to make sure it is a minimum 200-watt entrance.

      (3) Look for machinery and equipment arranged to permit safe, efficient work and cleaning ease.

   b. As you examine a shop area, you note the presence of properly stored flammable and corrosive materials in the shop area. The problem is, there is another obvious thing to look for, so you should:

      (1) Make sure lids are placed tightly on all chemical products.

      (2) Look for material safety data sheets to be kept on file so that they are accessible to all shop or lab personnel.

      (3) Look for readily accessible soap and water if first aid should every be required.

8. Select true statements about the fire triangle. Place an "X" beside each statement that is true.

______a. The fire triangle means fuel, heat, and oxygen required to start and maintain a fire.

______b. The heat in the fire triangle must be hot enough to sustain combustion.

______c. Simply removing any one element in the fire triangle will stop a fire regardless of the nature of heat of the fire.

Written Test

9. Match classes of fires with ways to put them out. Place the number beside the type of fire in the blank beside the description of the way to put the fire out.

______a. Since these are fires in ordinary combustibles such as wood, rags, and rubbish, they are easiest to extinguish with a pressurized water fire extinguisher.

______b. Since these are fires that occur in flammable liquids such as oil, gasoline, paints, and thinners, they need to be extinguished with a carbon dioxide (CO_2) fire extinguisher.

______c. Since these fires occur in or near electrical equipment such as wiring, switch panels, or motors, they should be extinguished with a dry chemical fire extinguisher; do not use pressurized water on an electrical fire.

______d. Since these fires occur in combustible metals such as magnesium, they should be extinguished with a dry chemical fire extinguisher; as with electrical fires, do not use pressured water on this class of fire.

______e. These fires can be fought with foam-filled extinguishers, or even with sand.

1. Class C fires
2. Class A fires
3. Class D fires
4. Class A and B fires
5. Class B fires

10. Solve problems about lifting safety. Circle the number beside the statement that best completes each of the following problems.

a. A technician doesn't lift a lot of heavy loads during the workday, but there is constant lifting of smaller items that require a lot of bending and moving. To avoid a back problem, the technician should:

(1) Always ask for help when there is something to lift.

(2) Size up each load before lifting it.

(3) Wear a back support belt that provides support for the lumbar or lower back region where most back pains and strains occur.

b. You have to move a long piece of duct work that you know will be hard to handle. A fellow technician volunteers to help you carry it, but to avoid a problem the two of you should:

  (1) Be sure each of you has a firm grip on the duct.

  (2) Place yourselves on either side of the duct to maintain stability and make foot movement easier.

  (3) Get hold of the duct as far back on each end as possible.

c. You are faced with having to move part of an outdoor unit that promises to be very difficult to lift, even if someone helps. To avoid a problem, you should:

  (1) Use a dolly, and strap the unit on tightly with a tiedown.

  (2) Place boards down and slide the unit to the new location.

  (3) Get at least three other technicians to help so the load will be better distributed.

11. Select true statements about guidelines for handling an accident. Place an "X" beside each true statement.

_______a. Follow your own common sense regarding the reporting of accidents and the administration of first aid or other services.

_______b. If the accident has resulted in bleeding, make sure you clean the area with a clean cloth.

_______c. In any accident, first make sure the victim is free from any other harm or danger, and if first aid is required, administer whatever first aid you can safely deliver.

_______d. Report the accident as soon as possible to your instructor, no matter how minor the accident may seem to be.

_______e. Write down the time of the accident, the name of the victim, the place of the accident, and any other noteworthy materials so that you can help make an accurate accident report.

_______f. Contact the victim's parents or friends as soon as possible to assure them that the victim is going to be okay.

Written Test

12. Select true statements about circuit amperages and their affects on the human body. Place an "X" beside each true statement.

______a. Low amperage circuits are safe to work around because they are not nearly as dangerous as high amperage circuits.

______b. When touched, a circuit of less then .5 milliamps usually produces no discernable sensation, but a circuit of 2 to 10 milliamps can cause muscular contraction.

______c. A circuit with 5 to 15 milliamps can cause painful shock and cause a person to be unable to let go.

______d. When circuit amperage is over 25 milliamps, it can cause violent muscular contraction.

______e. A circuit over 100 milliamps can burn and cause paralysis of breathing.

______f. A circuit of 50 to 200 milliamps can cause heart convulsions and death.

______g. Never, never disregard the power of a small amperage circuit; it is more dangerous than a higher amperage circuit.

13. Select true statements about guidelines for general electrical safety. Place an "X" beside each true statement.

______a. Do not under estimate the potential danger of any electrical circuit.

______b. Avoid electric arcs because they can badly burn your skin and eyes.

______c. Work on live circuits only when absolutely necessary, and remember that your involuntary reaction to electrical shock may cause you to hit something that causes more injury than the shock itself; you might also injure a coworker.

______d. Stand on dry, nonconductive surfaces when working with live circuits.

______e. Properly fuse all electrical lines, and bypass electrical protective devices only when you have to.

______f. When you install equipment that overloads a circuit, be sure to notify the owner about upgrading the electric service.

______g. Properly insulate electrical wiring, and keep electrical lines from refrigerant tubing by putting the electrical lines in conduit.

Written Test

______h. Check all circuits for voltages before doing any service work.

______i. Work in pairs when possible, and tag and lock out electrical disconnects so someone won't accidentally activate a circuit you're working with.

14. Complete statements about safety guidelines for using electrical tools. Circle the material that best completes each of the following statements.

    a. Have a ground on all power tools that do not have (**a polarized plug**) (**an internal disconnect**) with ground-fault protection.

    b. Use electrical cords of appropriate gauge and (**power**) (**length**).

    c. Have proper guards on electrical tools, and keep the guards (**in place**) (**clean at all times**).

    d. Do not use frayed or (**oversized**) (**damaged**) cords with electrical tools.

    e. Stand on dry, (**nonconductive**) (**wooden**) surfaces when using electrical tools.

    f. Wear eye glasses and/or (**eye glasses and a face shield**) (**other appropriate eye protection**) when working with electrical tools.

15. Match safety colors with their applications. Place the number beside the color in the blank that describes its application.

______a. Indicates the location of fire fighting equipment, flammable liquids, and emergency stop buttons or stop switches on machinery

______b. Indicates physical hazards, waste containers for combustible materials, and general cautions about equipment under repair

______c. Indicates dangerous parts of machines, especially exposed edges of pulleys, gears, rollers, cutting devices, and power jaws

______d. Indicates radiation hazards

1. Safety orange
2. Safety blue
3. Safety purple
4. Safety red
5. Safety black and white
6. Safety yellow
7. Safety green

Written Test

______e. Indicates location of first aid equipment, especially first aid kits and eye was stations

______f. Indicates cautions against starting equipment being worked on, and should be on an "Out of Order" tag

______g. Indicates traffic flow and housekeeping purposes and may be in combination

16. Match accident prevention signs with their applications and colors. Place the number beside the sign type in the blank beside the description of its application and colors.

______a. Warn of an immediate hazard; they have white letters on a red background over a white panel with black letters and black border

______b. Warn against potential hazards or unsafe practices; they have yellow letters over a red background over a yellow panel with black letters and a black border

______c. Indicate directions, instructions, or locations of safety stations; they have white letters on a green panel with a black border

1. Caution signs
2. Danger signs
3. Safety instruction signs

17. Match accident prevention tags with their applications and color schemes. Place the number beside the tag type in the blank beside the description of its application and color scheme.

______a. Are usually white or gray tags with white letters on a red square to indicate a starting mechanism that could be hazardous if the equipment is energized

______b. Are white tags with white letters on a red oval placed where an immediate hazard exists

1. Caution tags
2. Do not start tags
3. Out of order tags
4. Danger tags

______c. Are yellow tags with yellow letters on a black square to warn against potential hazards or to caution against unsafe practices

______d. Are white tags with white letters on a blue square; they are used to indicate equipment that is out of order and should not be used

18. Complete statements about what you should know about OSHA's *Hazard Communication Standard.* Circle the material that best completes each of the following statements.

    a. An OSHA regulation titled *Hazard Communication Standard* requires that all workers have available to them data about workplace (**solvents**) (**substances**) they work with and guidelines for first aid in case hazardous substances are accidentally spilled or misused.

    b. To assure compliance with OSHA regulations, manufacturers of chemicals and other substances prepare an MSDS (material safety data sheet) that must accompany each product sold and be kept (**near the product**) (**on file in the workplace**) so that it is always available to workers.

    c. When chemicals go from a manufacturer or wholesaler into the workplace, the business where the chemicals are used should have a (**chemical hygiene plan**) (**supply library**) that details use of chemicals, emergency measures in case of spills or leaks, and location of hygiene stations such as eye-washes and showers.

    d. Part of the health hazard information included in an MSDS lists routes of entry into the body; this means a chemical can be ingested through the (**mouth**) (**pores**), inhaled through the respiratory system, or absorbed through the skin.

    e. Some workplace chemicals are flammable, others are (**explosive**) (**corrosive**), others have volatile fumes, and some can severely affect eyes, nose, throat, heart, lungs, kidneys, and the central nervous system.

    f. Your right to know about workplace hazards is a (**responsibility**) (**law**), and if you are in a workplace or even a school lab that does not have an MSDS file, you should inform a responsible authority.

Written Test

19. Select true statements about how to protect yourself from hazardous substances in the workplace. Place an "X" beside each true statement.

_____a. Know what kinds of safeguards are present in the products you use.

_____b. Know how to protect yourself from being harmed by workplace chemicals.

_____c. Find out about the dangers of exposure to chemicals you use infrequently.

_____d. Read the Material Safety Data Sheets on file in the lab or shop, and ask questions about anything you don't understand.

20. Select true statements about what you should know about OSHA's *Bloodborne Pathogen Standard*. Place an "X" beside each true statement.

_____a. OSHA's *Bloodborne Pathogen Standard* details the procedures for controlling exposure to infectious materials in the workplace, but especially to cancer-causing chemicals.

_____b. The standard applies especially to health care workers, but it applies to all workplaces and requires engineering controls such as proper containers for the disposal of contaminated materials, and work practice controls such as changing the way a job is done to minimize exposure potential.

_____c. The standard also requires an employer to provide protective clothing such as gloves, masks, eye protection, and any protective equipment a particular job may require.

_____d. The standard also requires an employer to keep records of employee training, exposure incidents, post-exposure follow up, and hepatitis B vaccination status.

_____e. An important part of the standard concerns "universal precautions" which means that all exposures should be evaluated according to workplace conditions at the time of exposure.

21. Select true statements about other items related to the *Bloodborne Pathogen Standard*. Place an "X" beside each true statement.

_____a. Accidental exposure to bleeding does not always mean the exposure can transmit a pathogen; if the victim who is bleeding is not a carrier of HIV or HBV, there can be no exposure, and if there is no route of entry such as a cut or open area of skin, the employee exposed cannot contract a pathogen.

Written Test

______b. There are no vaccinations against HIV or HBV, so the need for this standard is doubly important.

______c. Influence of the standard should show up at many places in the workplace, especially with first aid kits; the kits need to include a supply of latex gloves, disposable towelettes containing an antimicrobial agent, a face shield for protected mouth-to-mouth resuscitation, and a container of antimicrobial liquid soap.

______d. Containers of regulated waste should have signs on them that say "Regulated Waste."

______e. Although the *Bloodborne Pathogen Standard* applies to the workplace, it has been adopted by many schools and is frequently administered by a Safety Officer or other trained health administrator.

*Permission to duplicate this test is granted.

Occupational Safety
Unit 2

Teacher Supplement 1—Helpful Telephone Numbers

The following telephone list should come in handy when you have questions about the new EPA refrigerant standards, certifications, procedures, and almost any matter that may arise. The list was published by the EPA in 1993, so some numbers and individual contacts may have changed.

EPA's Stratospheric Ozone Hotline 800-296-1996

Trade or Professional Association	Contact Person	Telephone #
Air Conditioning and Refrigeration Institute	Ed Dooley	703-524-8800
Air Conditioning Contractors of America	Ella Larson	202-483-9370
Alliance for Responsible CFC Policy	Dave Stirpe	703-243-0344
American Society of Heating, Refrigerating, and Air Conditioning Engineers	Technical Services	404-636-8400
American Subcontractors Association	Sarah Thomson	703-684-3450
American Supply Association	Public Affairs Office	312-464-0090
Association of Energy Engineers	Ruth Bennet	404-447-5083
Building Owners and Managers Association	Michael Jawer	202-408-2662
Chemical Manufacturers Association	Non-emergency services	800-262-8200
Chemical Refrigerator Manufacturers Association	Tim Rugh	202-857-1145
Electrical Power Research Institute	Information hotline Commercial Building Air Conditioning Center	415-855-2411 608-262-8223
Food Marketing Institute	Public Affairs Office	202-452-8444
International Association of Cold Storage Contractors	Public Affairs Office	202-452-1781
International Facility Management Association	Information Services	713-623-4362
Mechanical Service Contractors of America	Barbara Dolim	301-869-5800
National Association of Convenience Stores	Public Affairs Office	703-836-5464
National Association of Plumbing, Heating, and Cooling Contractors	Joanne Oxley	800-533-7694
Refrigeration Engineers and Technicians Association	Public Affairs Office	312-644-6610
Refrigeration Service Engineers Society	Dean Lewis	708-297-6464
Sheet Metal and Air Conditioning Contractors National Association	Public Affairs Office	703-803-2980

Occupational Safety
Unit 2

Teacher Supplement 2—The Bodily Fluid Disposal Kit

A Bodily Fluid Disposal Kit answers some of the workplace requirements of OSHA's *Bloodborne Pathogen Standard*. The kit will mostly be of use to health care organizations where the presence of blood in the workplace is a part of daily activity. However, the kit is equally at home around athletic activities and all activities where the potential for infected blood or bodily fluids is present. It is not far fetched to imagine that some air conditioning mechanics will from time to time find themselves working in environments where they may be requested to wear a face mask, latex gloves, or even shoe covers. The following gives you an idea of what is in a Bodily Fluid Disposal Kit and what those things protect against.

Absorbent granules absorb blood and bodily fluid spills.

Latex gloves protect the hands.

Chlorine bleach disinfects against bloodborne organisms.

Chlorhexidine towelettes disinfect hands after cleanup.

Goggles protect the eyes against splatters.

A face mask protects the nose and mouth from breathing in or ingesting contaminants.

An apron protects clothing from contamination.

Show covers prevent a spill from being spread.

Bag and tie provides for proper disposal of contaminated waste.

These materials are courtesy of Zee Medical, Inc., of Irvine, California.

Occupational Safety
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Interpret Important Information From a Materials Safety Data Sheet Rating _____

Comments: ____

____

Assignment Sheet 2—Complete a Worksheet About Bloodborne Pathogens Rating _____

Comments: ____

____

Assignment Sheet 3—Complete a Student Safety Pledge Rating _____

Comments: ____

____

Other ____

____

Written Tests: Pretest _____ Posttest _____

Total _____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Material Safety Data Sheet

SPARTAN CHEMICAL CO., INC.
MATERIAL SAFETY DATA SHEET

SECTION I: PRODUCT INFORMATION

PRODUCT NAME OR NUMBER (as it appears on label)
NABC PLUS IV

MANUFACTURER'S NAME
Spartan Chemical co., Inc.

EMERGENCY TELEPHONE NO.
419/531-5551

ADDRESS (NUMBER, STREET, CITY, STATE AND ZIP CODE)
110 N. Westwood Ave., Toledo, OH 43607

NFPA RATINGS:	HMIS RATINGS:
HEALTH-1 FIRE-0 REACT-0	HEALTH-1 FIRE-0 REACT-0 PERS. PROT.-B

SECTION II: HAZARDOUS INGREDIENTS

CAS REGISTRY NO.	*%W*	*CHEMICAL NAME(S)*	*TABLE Z-1-A*			*CARCINOGEN*
			TWA mg/M³	*STEL mg/M³*	*CEILING mg/M³*	
77-92-9	*1-5*	*Citric acid*	*--- Not established ---*			*No*

SECTION III: PHYSICAL DATA

BOILING POINT
200-210°F
VAPOR PRESSURE
18 MM hG @ 75°f
VAPOR DENSITY (AIR = 1)
Unknown
SOLUBILITY IN WATER
Complete
pH
1.5 - 2.0

SPECIFIC GRAVITY (H_2O = 1)
1.01

EVAPORATION RATE (but. ace. = 1)
<1

APPEARANCE AND ODOR
Blue viscous fluid,
floral odor

PERCENT SOLID BY WEIGHT
5-10

IS MATERIAL: (LIQUID) SOLID
GAS PASTE POWDER

SECTION IV: FIRE & EXPLOSION HAZARD DATA

FLASH POINT – None

METHOD USED — ASTM — D56

FLAMMABLE LIMITS — n/a

EXTINGUISHING MEDIA — n/a

SPECIAL FIRE FIGHTING PROCEDURES — None

UNUSUAL FIRE AND EXPLOSION HAZARDS — None known

Courtesy Spartan Chemical Co., Inc.

Occupational Safety
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Accident** — Any suddenly occurring, unintentional event which causes injury or damages property

    b. ***Bloodborne Pathogen Standard*** — An OSHA regulation designed to protect employees from the dangers of AIDS and other bloodborne diseases that may result from a blood-producing accident in the workplace

    c. **First aid** — Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

    d. ***Hazard Communication Standard*** — An OSHA regulation designed to protect employees from the dangers of chemicals and other hazardous substances in the workplace

    e. **MSDS (Material Safety Data Sheet)** — A written reference of any chemical used in a workplace, its potential for causing bodily harm, and an accompanying first aid guide; MSDSs are required by OSHA's *Hazard Communication Standard*

    f. **OSHA (Occupational Safety and Health Act)** — Federal legislation designed to insure safe and sanitary working conditions for all employees; the act is administered and enforced by the Occupational Safety and Health Administration

    g. **Pathogen** — A bacterium or virus that causes disease

    h. **Safety** — The state or condition of being safe from danger, risk, or injury

2. **Guidelines for personal lab safety**

    a. Wear safety glasses at all times and use the proper helmet or goggles when welding or brazing.

    b. Confine long hair and loose clothing before operating rotating equipment.

    c. Remove all metal jewelry before working in the shop.

    d. Use soap and water frequently to prevent skin irritations.

    e. Be safety conscious at all times, avoid all horseplay, and conduct yourself in a manner conducive to shop safety at all times.

Information Sheet

3. Guidelines for general shop safety

- a. Keep all hand tools sharp, clean, and in safe working condition, and report defective tools or machines to your instructor.
- b. Never operate potentially hazardous machines until you have been instructed how to use the machine and have your instructor's permission to use the machine.
- c. In addition to wearing safety glasses, wear goggles, gloves, shoes, and aprons, or other appropriate clothing when working with hazardous materials or equipment.
- d. Keep the lab floor clean of scraps and litter, and report spilled liquids immediately so they can be properly removed.
- e. Even if you mean to just play around, never throw an object for any reason, consider the safety of your co-workers, and remember that horseplay is strictly outlawed in a class or lab.
- f. Read the material safety data sheets for every chemical or hazardous material that you have to work with and know what first aid procedures to follow if the chemical is misused or accidentally spilled.

4. Guidelines for machine safety

- a. Make sure all guards and barriers are in place before starting a machine.
- b. Clean chips from a machine only with a brush, not with a towel, your bare hands, or with compressed air.
- c. Disconnect power from the machine before oiling or cleaning or any other maintenance work.
- d. Never leave a running machine unattended even for a second, and turn off the power before leaving a machine.
- e. If a machine exhibits dangerous performance, stop immediately, disconnect the power, and tag the machine with a "Do Not Start" or "Out of Order" tag and report the bad equipment to your instructor.

Information Sheet

5. **Guidelines for solvent safety**

   a. Use a solvent only after determining where it should be used and how it should be used.

   b. Clean up spilled solvent immediately, if you can safely do so, and report the accident to your instructor.

   c. Use solvents only in properly ventilated areas, and avoid letting solvent vapors get on your skin or in your eyes.

   d. If your hands, arms, or other body parts are exposed to solvents, wash with soap and water as soon as possible, and be sure to wash well.

   e. Store towels used for solvents or towels with oily waste in approved metal containers.

   Note: Many shops have oily rags and solvent-exposed rags picked up every week or more often by companies that specialize in the safe disposal of potentially dangerous cleaning materials.

6. **Guidelines for workplace electrical safety**

   a. Do not work with frayed electrical cords of any kind; repair or replace cords as needed.

   b. Avoid dragging extension or drop cords through dirt or oil, and if cords are accidentally dirtied, clean them before using them.

   c. Never run over an extension cord or a drop cord with a dolly or service cart.

   d. Never, never cut off the grounding prong on an electrical plug, and avoid using outlets that are not properly grounded.

7. **Characteristics of a clean and orderly shop**

   a. Machinery and equipment arranged to permit safe, efficient work and cleaning ease.

   b. Materials and supplies are safely stacked or stored.

   c. Tools and accessories are safely stored in cabinets, on racks, or other suitable places.

   d. Working areas and work benches are free of clutter and debris.

   e. Floors are clean, and free from slippery substances and obstructions.

   f. Aisles, traffic areas, and exits are well marked and free of debris.

Information Sheet

g. Combustible materials are properly stored or disposed of, and oily rags are placed in safe containers.

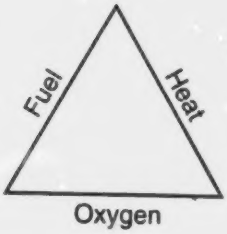
h. Brooms, brushes, and other housekeeping equipment is readily available in sufficient supply.

i. The drinking fountain and eye-wash station are neat and clean at all times.

j. Material safety data sheets are to be kept on file and are readily accessible to all shop or lab personnel.

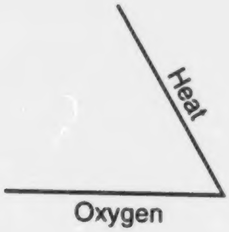
8. **The fire triangle**

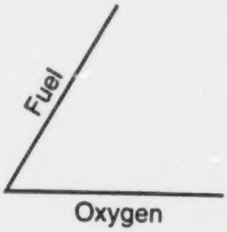
a. Generally speaking, fuel, heat, and oxygen are required to start and maintain a fire, and the condition is often referred to as the fire triangle.

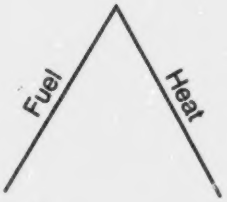


b. The fuel can be any combustible material, the heat must be hot enough to raise the fuel to its ignition point, and there must be enough oxygen to sustain combustion.

c. In theory, if any one item in the fire triangle is removed, the fire will be extinguished, but the nature of the fuel and the heat of the fire always have to be considered, so the best way to fight a fire is not with theory, but with a fire extinguisher properly charged to fight the fire.



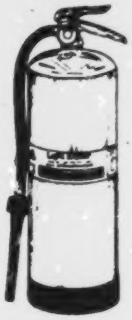




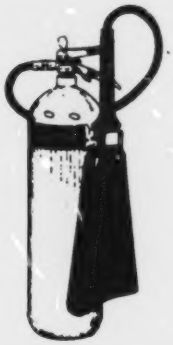
Information Sheet

9. **Classes of fires and ways to put them out**

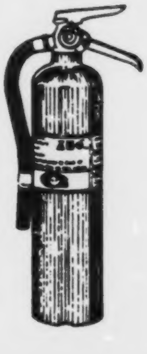
   a. **Class A fires** — Since these are fires in ordinary combustibles such as wood, rags, and rubbish, they are easiest to extinguish with a pressurized water fire extinguisher.



   b. **Class B fires** — Since these are fires that occur in flammable liquids such as oil, gasoline, paints, and thinners, they need to be extinguished with a carbon dioxide (CO_2) fire extinguisher.



   c. **Class C fires** — Since these fires occur in or near electrical equipment such as wiring, switch panels, or motors, they should be extinguished with a dry chemical fire extinguisher; do not use pressurized water on an electrical fire.



Information Sheet

d. **Class D fires** — Since these fires occur in combustible metals such as magnesium, they should be extinguished with a dry chemical fire extinguisher; as with electrical fires, do not use pressured water on Class D fires.

e. **Class A and B fires** — These fires can be fought with foam-filled extinguishers, or even with sand.

10. **Lifting safety**

    a. Back problems are the number one claim in workers compensation cases, and the problem does not always stem from overstrain caused by trying to lift too heavy a load.

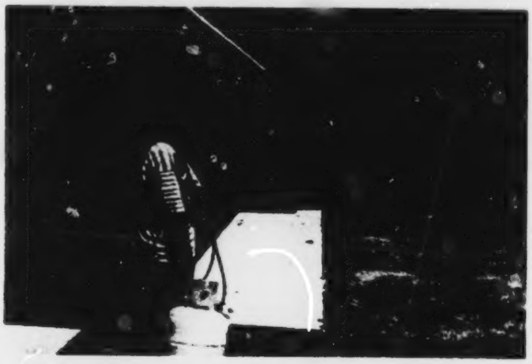
    b. Many back problems result from repeated lifting of lighter loads, or lifting from a clumsy body position and failure to use leg and back muscles together.

    c. When lifting a load, position yourself in a comfortable position, bend your knees, and then lift straight up with a combination of leg and back power; do not try to lift only with your arm strength.

    d. Any technician who has to lift more than a few times in a workday should wear a back support belt that provides support for the lumbar or lower region of the spine where most back pains and strains occur.

Information Sheet

e. Back support belts can help avoid back strain when used properly, but they will in no way help you lift a heavier load.



f. When a load is unwieldy, too long, or bulky, get a coworker to help carry it, and place yourselves on either side of the load to maintain stability and make foot movement easier.

g. When a load is really heavy, move it with a dolly or a Hi-Jack dolly/lifter made especially for ACR work; one person can operate the Hi-Jack which can be configured to lift loads as high as 17 feet.

Information Sheet

h. In all cases, know where you're going with a load before you pick it up, and make sure the route to your destination is free of obstructions.

11. **Guidelines for handling an accident**

    a. Know and follow all local school policies regarding the reporting of accidents and the administration of first aid or other services.

    b. If the accident has resulted in bleeding, get a pair of latex gloves out of the first aid kit and put them on before you touch the victim.

    c. Continue by making sure the victim is free from any other harm or danger, and if first aid is required, administer whatever first aid you can safely deliver.

    d. Report the accident as soon as possible to your instructor, no matter how minor the accident may seem to be.

    e. Write down the time of the accident, the name of the victim, the place of the accident, and any other noteworthy materials so that you can help make an accurate accident report.

    f. Do not contact the victim's parents or friends outside the school because this is the responsibility of a school nurse, a doctor, or a designated school authority.

12. **Circuit amperages and their affects on the human body**

    a. When conditions are right, even low amperage circuits are dangerous to work with, and require special attention.

    b. When touched, a circuit of less than .5 milliamps usually produces no discernable sensation, but a circuit of 2 to 10 milliamps can cause muscular contraction.

    c. A circuit with 5 to 15 milliamps can cause painful shock and cause a person to be unable to let go.

    d. When circuit amperage is over 25 milliamps, it can cause violent muscular contraction.

    e. A circuit over 100 milliamps can burn and cause paralysis of breathing.

    f. A circuit of 50 to 200 milliamps can cause heart convulsions and death.

    g. Never, never diregard the power of a small amperage circuit; all circuits are dangerous!

Information Sheet

13. Guidelines for general electrical safety

a. Do not underestimate the potential danger of any electrical circuit.

b. Avoid electric arcs because they can badly burn your skin and eyes.

c. Work on live circuits only when absolutely necessary, and remember that your involuntary reaction to electrical shock may cause you to hit something that causes more injury than the shock itself; you might also injure a coworker.

d. Stand on dry, nonconductive surfaces when working with live circuits.

e. Properly fuse all electrical lines, and never bypass an electrical protective device.

f. Refuse to install equipment that will overload a circuit; make sure all electrical wiring complies with applicable national or local codes.

g. Properly insulate electrical wiring, and keep electrical lines from refrigerant tubing by putting the electrical lines in conduit.

h. Check all circuits for voltages before doing any service work.

i. Work in pairs when possible, and tag and lock out electrical disconnects so someone won't accidentally activate a circuit you're working with.

14. Safety guidelines for using electrical tools

a. Have a ground on all power tools that do not have a polarized plug with ground-fault protection.

b. Use electrical cords of appropriate gauge and length.

c. Have proper guards on electrical tools, and keep the guards in place.

d. Do not use frayed or damaged cords with electrical tools.

e. Stand on dry, nonconductive surfaces when using electrical tools.

f. Wear eye glasses and/or other appropriate eye protection when working with electrical tools.

Information Sheet

15. Safety colors and their applications

a. **Safety red** — Indicates the location of fire fighting equipment, flammable liquids, and emergency stop buttons or stop switches on machinery

b. **Safety yellow** — Indicates physical hazards, waste containers for combustible materials, and general cautions about equipment under repair

c. **Safety orange** — Indicates dangerous parts of machines, especially exposed edges of pulleys, gears, rollers, cutting devices, and power jaws

d. **Safety purple** — Indicates radiation hazards

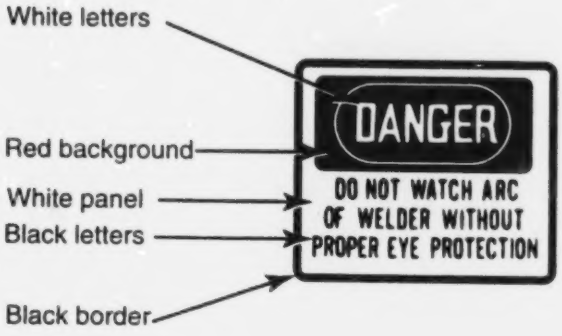
e. **Safety green** — Indicates location of first aid equipment, especially first aid kits and eye wash stations

f. **Safety blue** — Indicates cautions against starting equipment being worked on, and should be on an "Out of Order" tag

g. **Safety black or white** — Indicates traffic flow and housekeeping purposes and may be in combination

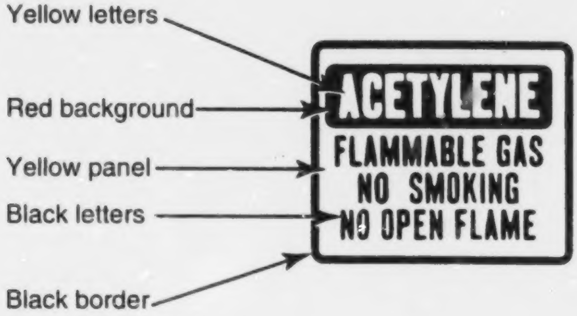
16. Accident prevention signs, their applications and colors

a. **Danger signs** — Warn of an immediate hazard; they have white letters on a red background over a white panel with black letters and a black border

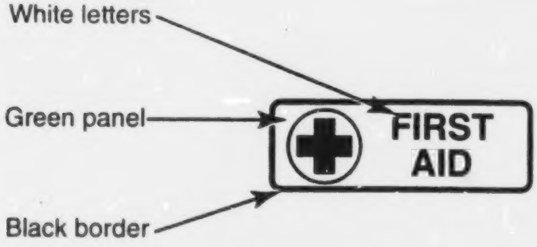

White letters
Red background
White panel
Black letters
Black border
DANGER
DO NOT WATCH ARC
OF WELDER WITHOUT
PROPER EYE PROTECTION

Information Sheet

b. **Caution signs** — Warn against potential hazards or unsafe practices; they have yellow letters over a red background over a yellow panel with black letters and a black border

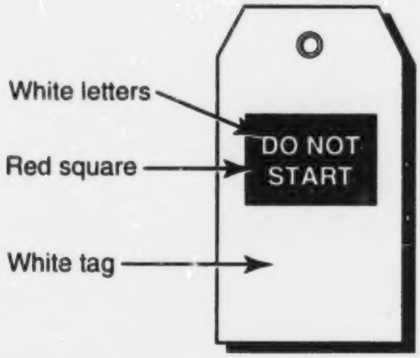

Yellow letters
Red background
Yellow panel
Black letters
Black border
ACETYLENE
FLAMMABLE GAS
NO SMOKING
NO OPEN FLAME

c. **Safety instruction signs** — Indicate directions, instructions, or locations of safety stations; they have white letters on a green panel with a black border


White letters
Green panel
Black border
FIRST
AID

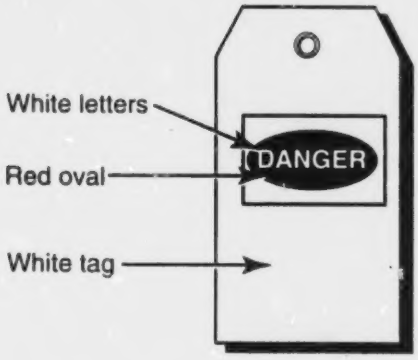
17. Accident prevention tags, their applications and color schemes

a. **Do not start tags** — Are usually white or gray tags with white letters on a red square to indicate a starting mechanism that could be hazardous if the equipment is energized

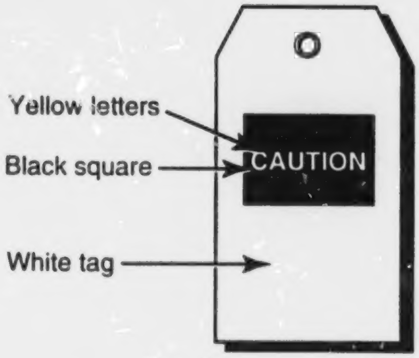

White letters
Red square
White tag
DO NOT
START

Information Sheet

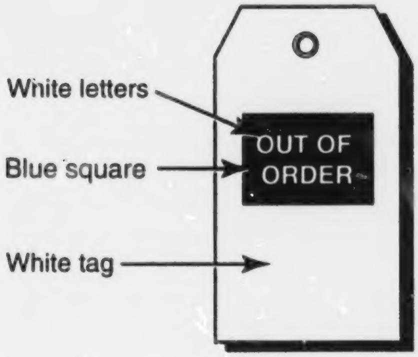
b. **Danger tags** -- Are white tags with white letters on a red oval placed where an immediate hazard exists


White letters
Red oval
White tag
DANGER

c. **Caution tags** — Are yellow tags with yellow letters on a black square to warn against potential hazards or to caution against unsafe practices


Yellow letters
Black square
White tag
CAUTION

d. **Out of order tags** — Are white tags with white letters on a blue square; they are used to indicate equipment that is out of order and should not be used


White letters
Blue square
White tag
OUT OF ORDER

Information Sheet

18. What you should know about OSHA's *Hazard Communication Standard*

a. An OSHA regulation titled *Hazard Communication Standard* requires that all workers have available to them data about workplace substances they work with and guidelines for first aid in case hazardous substances are accidentally spilled or misused.

b. To assure compliance with OSHA regulations, manufacturers of chemicals and other substances prepare an MSDS (material safety data sheet) that must accompany each product sold and be kept on file in the workplace so that it is always available to workers.

c. When chemicals go from a manufacturer or wholesaler into the workplace, the business where the chemicals are used should have a chemical hygiene plan that details use of chemicals, emergency measures in case of spills or leaks, and location of hygiene stations such as eye-washes and showers.

d. Part of the health hazard information included in an MSDS lists routes of entry into the body; this means a chemical can be ingested through the mouth, inhaled through the respiratory system, or absorbed through the skin.

e. Some workplace chemicals are flammable, others are corrosive, others have volatile fumes, and some can severely affect eyes, nose, throat, heart, lungs, kidneys, and the central nervous system.

f. Your right to know about workplace hazards is a law, and if you are in a workplace or even a school lab that does not have an MSDS file, you should inform a responsible authority.

19. How to protect yourself from hazardous substances in the workplace

a. Know what kinds of chemicals are present in the products you use.

b. Know how to protect yourself from being harmed by workplace chemicals.

c. Find out about the dangers of exposure to chemicals you use repeatedly.

d. Read the Material Safety Data Sheets on file in the lab or shop, and ask questions about anything you don't understand.

Note: The MSDS should contain a telephone number you can call for further information about a product. Be sure to have your instructor's permission to place such a call, and be sure you call the correct number because the MSDS will also have a number for first aid emergencies only.

Information Sheet

20. **What you should know about OSHA's *Bloodborne Pathogen Standard***

    a. OSHA's *Bloodborne Pathogen Standard* details the procedures for controlling exposure to infectious materials in the workplace, but especially to the accidental exposure to HBV, hepatitis B virus, and HIV, human immunodeficiency virus.

    b. The standard applies especially to health care workers, but it applies to all workplaces and requires engineering controls such as proper containers for the disposal of contaminated materials, and work practice controls such as changing the way a job is done to minimize exposure potential.

    c. The standard also requires an employer to provide protective clothing such as gloves, masks, eye protection, and any protective equipment a particular job may require.

    d. The standard also requires an employer to keep records of employee training, exposure incidents, post-exposure follow up, and hepatitis B vaccination status.

    e. An important part of the standard concerns "universal precautions" which means that all human blood and certain human body fluids be treated as if they are known to be infectious for HIV, HBV, or other bloodborne pathogens.

21. **Other items related to the *Bloodborne Pathogen Standard***

    a. Accidental exposure to bleeding does not always mean the exposure can transmit a pathogen; if the victim who is bleeding is not a carrier of HIV or HBV, there can be no exposure, and if there is no route of entry such as a cut or open area of skin, the employee exposed cannot contract a pathogen.

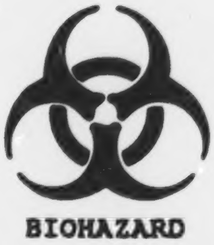
    b. There are no vaccinations against HIV, but there is a vaccination for HBV, and as part of employee training, the standard requires employees be given the opportunity, at no cost, to receive a vaccination.

    c. Should employees decline the hepatitis vaccination, they are required to sign a declination document indicating that they have been given an opportunity to receive the vaccination at no cost, but have decided not to take the vaccination.

    d. Influence of the standard should show up at many places in the workplace, especially with first aid kits; the kits need to include a supply of latex gloves, disposable towelettes containing an antimicrobial agent, a face shield for protected mouth-to-mouth resuscitation, and a container of antimicrobial liquid soap.

Information Sheet

e. Containers of regulated waste should be marked with labels of fluorescent orange or orange-red to indicate that they contain potentially hazardous material which is generally called a biohazard.



f. Although the *Bloodborne Pathogen Standard* applies to the workplace, it has been adopted by many schools and is frequently administered by a Safety Officer or other trained health administrator.

Note: Your instructor should inform you about school policy in reference to the standard.

Occupational Safety
Unit 2

Student Supplement 1—Material Safety Data Sheets

Because the workplace is filled with toxic products that pose hazards to employees, OSHA developed a *Hazard Communication Standard* which requires manufacturers to provide written information to help identify toxic materials in the workplace, how to safely work with the materials, and how to administer appropriate first aid if materials become, for any reason, a threat to life, health, or the environment. This written information should accompany the product, and should be placed on file with other Material Safety Data Sheets that are readily available to workers in the workplace. What's more, employees should be given training for the safe use of all chemicals or substances they use in the workplace, and this training should include first aid. Important parts of the *Hazard Communication Standard* include:

Label Requirements

Labels should identify the product, hazards associated with use of the product, the name of the manufacturer of the product.

Material Safety Data Sheet (From Form OSHA-20. Actual forms may vary)

Section I: General Information

This section identifies the product with a scientific formula and name along with the name or synonyms under which the product is commercially marketed. The manufacturer's name should be included with the date the product was prepared and a company contact and an emergency telephone number.

Section II: Hazardous Ingredients

This section lists product ingredients by name and percentage, paints, preservatives, and solvents; alloys and metallic contents, and hazardous mixtures of other liquids, solids, or gases.

Section III: Physical Data

This section lists boiling point, vapor pressure, vapor density, solubility in water, appearance (color) and odor, and other physical entities such as specific gravity.

Section IV: Fire and Explosion Hazard Data

This section lists flast point, what kind of extinguisher or agent to use to extinguish the fire, special fire fighting procedures, and unusual fire and explosion hazards such as an indication that a combustible liquid might explode if not kept cool.

Student Supplement 1

Section V: Health Hazard Data

This section lists threshold limits, effects of overexposure, and emergency first aid procedure.

Section VI: Reactivity Data

This section indicates whether the product is stable or unstable, conditions such as fires or hot surfaces to avoid, and materials to avoid because of incompatibility, materials such as strong oxidants, hot reactive metals, and powdered aluminum. The section also lists products that may result from hazardous decomposition, hazards such as phosgene gas.

Section VII: Spill or Leak Procedures

This section details steps to be taken in case of a spill and how to dispose of substances if they are subject to federal, state, or local disposal procedures.

Section VIII: Special Protection Information

This section specifies if the product requires respiratory protection and what kind, if any special ventilation is required, if gloves are required and what type, what type of eye protection is required, and any special clothing requirements such as lab coat or apron.

Section IX: Special Precautions

This section will indicate special handling or storage requirements and other precautions such as simple directions to wash after handling.

Other Important MSDS Matters

Workers who handle or will handle products covered by the *Hazard Communication Standard* should be given formal training to include:

1. The requirements of the standard
2. How to detect the presence of hazardous chemicals
3. How to read and understand chemical labels and MSDS forms
4. Methods of protection from chemicals
5. The administration of basic first aid for accidents

Occupational Safety
Unit 2

Assignment Sheet 1—Interpret Important Information on a Materials Safety Data Sheet

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of items completed	_____
Number of items correctly answered	_____

Directions: Carefully read the MSDS that accompanies this assignment sheet. The product is an industrial grade cleanser and disinfectant. Answer the following questions:

a. What is the name of the product as it appears on the label? ____________

b. What is the manufacturer's name? ____________

c. What phone number would you call if you needed more product information? ____________

____

d. What is the appearance and odor of the product? ____________

e. To what degree is the product soluble in water? ____________

f. What special fire fighting procedure would this product demand? ____________

g. Does this product have unusual fire and explosion hazards? ____________

h. What primary route of entry into the body does this product take? ____________

i. What first aid is recommended if the product is swallowed? ____________

____

j. What first aid is recommended for eye or skin contact with the product? ____________

____

Assignment Sheet 1

k. What is recommended for a product spill, and what is the disposal method? ______

______

______

l. What are the ventilation requirements when using this product? ______

______

m. What precautions are required for handling and storing this product? ______

______

Assignment Sheet 1

SPARTAN CHEMICAL CO., INC.
MATERIAL SAFETY DATA SHEET

SECTION I: PRODUCT INFORMATION

PRODUCT NAME OR NUMBER (as it appears on label)
NABC PLUS IV

MANUFACTURER'S NAME
Spartan Chemical co., Inc.

EMERGENCY TELEPHONE NO.
419/531-5551

ADDRESS (NUMBER, STREET, CITY, STATE AND ZIP CODE)
110 N. Westwood Ave., Toledo, OH 43607

NFPA RATINGS:	HMIS RATINGS:
HEALTH-1 FIRE-0 REACT-0	HEALTH-1 FIRE-0 REACT-0 PERS. PROT.-B

SECTION II: HAZARDOUS INGREDIENTS

CAS REGISTRY NO.	*%W*	*CHEMICAL NAME(S)*	*TABLE Z-1-A*			*CARCINOGEN*
			TWA mg/M³	*STEL mg/M³*	*CEILING mg/M³*	
77-92-9	*1-5*	*Citric acid*	*--- Not established ---*			*No*

SECTION III: PHYSICAL DATA

BOILING POINT
200-210°F
VAPOR PRESSURE
18 MM hG @ 75°f
VAPOR DENSITY (AIR = 1)
Unknown
SOLUBILITY IN WATER
Complete
pH
1.5 - 2.0

SPECIFIC GRAVITY (H_2O = 1)
1.01

EVAPORATION RATE (but. ace. = 1)
<1

APPEARANCE AND ODOR
Blue viscous fluid,
floral odor

PERCENT SOLID BY WEIGHT
5-10

IS MATERIAL: (LIQUID) SOLID
GAS PASTE POWDER

SECTION IV: FIRE & EXPLOSION HAZARD DATA

FLASH POINT – None

METHOD USED — ASTM — D56

FLAMMABLE LIMITS — n/a

EXTINGUISHING MEDIA — n/a

SPECIAL FIRE FIGHTING PROCEDURES — None

UNUSUAL FIRE AND EXPLOSION HAZARDS — None known

Courtesy Spartan Chemical Co., Inc.

Assignment Sheet 1

SECTION V: HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE — CONDITIONS TO AVOID **THRESHOLD LIMIT VALUE** — Not established
May cause eye and skin irritation. Harmful if swallowed. Do not get in eyes or skin. Avoid contamination of food.

PRIMARY ROUTES OF ENTRY INHALATION ___ **SKIN CONTACT** ___ **OTHER (SPECIFY)** ________

CONDITIONS AGGRAVATED BY USE — Unknown

EMERGENCY AND FIRST AID PROCEDURES — **INGESTION**: If swallowed, drink large quantities of water. **EYES**: In case of contact, immediately flush eyes with plenty of water for 15 minutes. If irritation persists, seek medical attention. **SKIN**: In case of contact, immediately flush skin with plenty of water for 15 minutes. If irritation persists, seek medical attention.

SECTION VI: REACTIVITY DATA

STABILITY: **UNSTABLE** ___
STABLE ___

INCOMPATIBILITY (MATERIALS TO AVOID) — Strong alkalis

HAZARDOUS DECOMPOSITION PRODUCTS — None known

HAZARDOUS POLYMERIZATION: **MAY OCCUR** ___
WILL NOT OCCUR ___

SECTION VII: SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED — Small quantities may be flushed with large amounts of water into sanitary sewer. Larger quantities should be picked up with absorbent material and disposed of in accordance with Federal, state, and local regulations.

WASTE DISPOSAL METHOD — Same as above.

SECTION VIII: SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFY TYPE) — None required

VENTILATION — Good general ventilation should be sufficient for most conditions. Local ventilation may be necessary for some operations.

PROTECTIVE GLOVES (SPECIFY TYPE)
Acid resistant

EYE PROTECTION (SPECIFY TYPE)
Safety glasses

OTHER PROTECTIVE EQUIPMENT — None necessary

SECTION IX: SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING — Nothing special
OTHER PRECAUTIONS — None

Spartan Chemical Co., Inc.
NABC PLUS IV
Ref: 29 CFR 1910:1200 (OSHA)

NAME Thomas J. Mitchell
TITLE Director of Research
DATE July 13, 1993
SUPERSEDES December 10, 1992

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Courtesy Spartan Chemical Co., Inc.

Occupational Safety
Unit 2

Assignment Sheet 2—Complete a Worksheet About Bloodborne Pathogens

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of entries completed	_____
Number of entries correct	_____

Directions: The following scenarios reflect accidents or incidents that do happen in the workplace. Circle the number of the item that includes the best response to containing bloodborne pathogens.

a. An employee who has been cut and accidentally gets blood on the arm of a coworker who is standing nearby. This means that the coworker:

   (1) Has been exposed to HIV or HBV.

   (2) May be exposed if she or he has a skin opening through which the blood could enter the body, and if the cut employee is a carrier of a pathogen.

   (3) The coworker on whom the blood accidentally spilled should have the blood washed off with a germicidal soap.

b. Your supervisor at work informs you that you can have a free vaccination to guard you against hepatitis B. You should:

   (1) Take the vaccination, or decline the vaccination and sign a declination statement.

   (2) Wait until you have talked with someone who has had the vaccination and find out if there are any dangers associated with it.

   (3) Take the vaccination without question.

Assignment Sheet 2

c. An accident has left a coworker with an abrasion that has produced not only blood, but other bodily fluids. The correct response is to:

   (1) Help the coworker clean and bandage the wound.

   (2) Use the "universal precaution" rule and treat all human blood and body fluids as if they are known to be infectious.

   (3) Get a sample of the blood so it can be tested to see if the coworker is a carrier.

d. A coworker has had only a slight scratch, but it has left a slight amount of blood. The scratch is on the backside of an arm which would be difficult for the coworker to reach. To help, you should:

   (1) Report the accident to your supervisor.

   (2) Get a pair of latex gloves out of the first aid kit, put them on, clean the scratch and cover it with a bandaid or bandage.

   (3) Have the coworker wash the scratch off in hot water.

Occupational Safety
Unit 2

Assignment Sheet 3—Complete a Student Safety Pledge

Name ______________________ Overall Rating ______________

Evaluation criteria	**Rating**
Student signature correct and dated	______
Parent or guardian signature correct and dated	______

Directions: The student safety pledge included with this assignment sheet is designed for the protection of the school, the program, and especially for your protection. Please take it home to your parent or guardian and have them read and sign it. Be sure to date all signatures.

Assignment Sheet 3

Student Safety Pledge

____, who is enrolled in

vocational ____________________ at ____________________________
will operate machines as part of the shop experience. For the student to participate in machine operation requires written permission from a parent or, if under 18, from a guardian.

It is understood that prior to operating equipment, the student will be given proper instruction in its use, complete with safety procedures required for operation. The student must be aware of these special shop procedures and accept responsibility for following safe practices while operating equipment. The student is therefore asked to subscribe to and sign the following safety pledge.

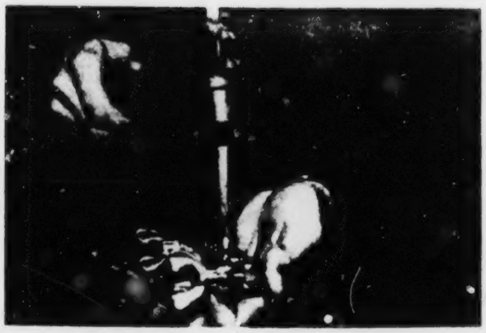
1. **I promise to follow all safety rules of the shop.**
2. **I promise never to use a machine without first having permission from my instructor.**
3. **I will not ask permission to use a particular machine unless I have been instructed in its use, and have scored 100% on a safety test about the machine.**
4. **I will report any accident or injury to my teacher immediately.**
5. **I understand that failure to comply with these rules will lead to appropriate disciplinary action.**

Date ________________ Student Signature ____________________________

I hereby give consent for my son/daughter to operate all machines and equipment necessary for carrying out the requirements of the course.

Date ________________ Parent or Guardian Signature ________________________

Parents and Guardians are cordially invited to visit the shop to inspect and watch machines and equipment in operation. Please arrange your visit in advance.



Hand Tools
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify selected hand tools. The student should demonstrate this competency by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to hand tools with their correct definitions.
2. Solve problems about types of screwdrivers and their uses.
3. Match types of wrenches with their uses.
4. Solve problems about types of pliers and their uses.
5. Match types of hammers with their uses.
6. Solve problems about punches, chisels, and bars and their uses.
7. Match types of files with their uses.
8. Solve problems about socket sets and their uses.
9. Solve problems about tubing tools and their uses.
10. Match threading tools with their uses.
11. Match other hand tools with their uses.
12. Complete statements about guidelines for using basic hand tools safely.
13. Complete statements about guidelines for using other hand tools safely.
14. Identify selected hand tools and describe their uses. (Assignment Sheet 1)

Hand Tools
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make a transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Screwdrivers (Objective 2)
   TM 2—Wrenches (Objective 3)
   TM 3—Pliers (Objective 4)
   TM 4—Hammers (Objective 5)
   TM 5—Punches, Chisels, and Bars (Objective 6)
   TM 6—Files (Objective 7)
   TM 7—Socket Sets (Objective 8)
   TM 8—Tubing Tools (Objective 9)
   TM 9—Other Hand Tools (Objective 10)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the assignment sheet. Review criteria for evaluation of this activity.

11. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet rating, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Impress upon students the importance of using proper tools for the job at hand, not only for better performance, but especially for safety to the individual and to expensive equipment. Skill areas: **Learning skills, learning to learn.**

2. Read Assignment Sheet 1 carefully and prepare and tag tools for students to examine. The important element here is that students must demonstrate that they not only know the tool, but know what it is used for. Skill areas: **Foundation skills, writing.**

3. Review Teacher Supplements 1 and 2. These have been prepared as job sheets so you can use them as job sheets in this unit or use them for demonstration only. The supplements may be reproduced as needed. Using taps and dies may not be a common activity around residential applications, but in commercial applications, it is a skill that is required often. Skill areas: **Foundation skills, science.**

Resources Used In Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *Paxton/Patterson Graves-Humphreys Catalog 93.* Chicago, IL: Paxton/Patterson, 1993.

3. *The Air Conditioning, heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1993.

Suggested Activities

4. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1. Coastal Video dedicates part of its "Ergonomics" video series to a 20-minute program titled "Proper Use of Hand Tools." This special video can be purchased outright or rented for a nominal fee. Cost includes ten employee handbooks, and the entire program, video/handbook is available in Spanish. For information call 1-800-767-7703 or write:

   Coastal Video Communications Corp.
   3083 Brickhouse Court
   Virginia Beach, VA 23452

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Hand Tools
Unit 3

Answers to Assignment Sheet

Assignment Sheet 1—Evaluate according to criteria presented in the assignment sheet. Answers will vary with types of tools selected.

Hand Tools
Unit 3

Answers to Written Test

1. a. 3
   b. 2
   c. 5
   d. 6
   e. 1
   f. 4

2. a. (2)
   b. (3)

3. a. 5
   b. 3
   c. 6
   d. 1
   e. 4
   f. 2

4. a. (3)
   b. (1)

5. a. 3
   b. 4
   c. 1
   d. 2

6. a. (3)
   b. (2)

7. a. 4
   b. 2
   c. 1
   d. 3
   e. 5

8. a. (1)
   b. (3)

9. a. (2)
   b. (1)

10. a. 2
    b. 1
    c. 4
    d. 3
    e. 5
    f. 7
    g. 8
    h. 6

Answers to Written Test

11. a. 4
    b. 8
    c. 7
    d. 1
    e. 5
    f. 3
    g. 2
    h. 6

12. a. any tool
    b. discard
    c. screwdriver
    d. both hands
    e. on the side
    f. insulated
    g. proper
    h. mushrooming
    i. in a wall rack
    j. handle

13. a. cheater bar
    b. no other purpose
    c. cutting
    d. loose in a drawer
    e. when they become dull
    f. cart
    g. screw starters
    h. cardboard

Hand Tools
Unit 3

Written Test

Name ______________________ Date ____________ Score ______

1. Match the terms on the right with their correct descriptions.

   ______a. Tools that are manipulated by hand with a combination of muscle power and operator skill

   ______b. A standard established by the Society of Automotive Engineers to identify a type of thread used in precision work

   ______c. A thread type used for general purpose applications

   ______d. Highly portable tools that are manipulated by an operator and powered by battery or through an electrical extension cord

   ______e. A tool designed for specific use or uses

   ______f. A tube enlarged on one end so that another tube the same size will fit into it

   1. Specialized tool
   2. National fine
   3. Hand tools
   4. Swage
   5. National coarse
   6. Powered hand tools

2. Solve problems about types of screwdrivers and their uses. Circle the number of the item that best solves each of the following problems.

   a. You need the proper screwdriver to secure a drill in place. You note that the screws have an indention that looks like a figure 8. To do the job right, you should:

      (1) Select a torx-head screwdriver.

      (2) Select a clutch-head screwdriver.

      (3) Use a pair of pliers to save time.

Written Test

b. You need to tighten a Phillips-head screw, but the screw is so close to the side of the air unit that you can't use a long-bladed screwdriver. To do the job right, you should:

   (1) Select an offset screwdriver.

   (2) Select any stubby screwdriver.

   (3) Select a stubby Phillips-head screwdriver.

3. Match types of wrenches with their uses. Place the number beside the type of wrench in the blank beside the description of its use.

______a. For working with hex-head bolts, nuts, or screws

______b. A wrench with flat interior surfaces so that it is less likely to slip off when working with hex-head bolts, nuts, or screws when added torque is applied

______c. A wrench with an open end and a box end for convenience of an operator who may need an open end for speed and a box end for added torque

______d. For working with hex-head bolts, nuts, and screws of varied sizes

______e. For working with pipe, pipe fittings, and other rounded surfaces

______f. For working with hex-head nuts, bolts, or screws; the open end permits the wrench to slip over tubing

1. Adjustable open end
2. Flare nut
3. Box end
4. Pipe
5. Open end
6. Combination

Written Test

4. Solve problems about types of pliers and their uses. Circle the number of the item that best solves each of the following problems.

   a. You need to crimp refrigeration tubing wo you can solder on a line without losing refrigerant. You should:

      (1) Play it safe and evacuate the system first.

      (2) Crimp the line closed with a pair of slip-joint pliers.

      (3) Crimp the line closed with a pinch-off wrench.

   b. You need to cut a wire so you can strip the end for splicing, and you also need to cut away a short piece of tin that could be sharp enough to cut the wire after you splice it. You should:

      (1) Cut the wire with diagonal cutters, but use tin snips to cut the tin.

      (2) Cut the wire with diagonal cutters, and save time using the cutters to cut the tin too.

      (3) Cut the wire and the tin with tin snips.

5. Match types of hammers with their uses. Place the number beside the type of hammer in the blank beside the description of its use.

   ______a. For hammering metal tools such as punches and chisels

   ______b. Made of plastic, rubber, rawhide, or material that will not mar or break other tools or materials being hammered

   ______c. Made with a heavy steel head and a long handle for breaking or pounding with substantial force

   ______d. For driving or pulling nails

   1. Sledge
   2. Claw
   3. Ball peen
   4. Soft face

Written Test

6. Solve problems about punches, chisels, bars, and their uses. Circle the number of the item that best solves each of the following problems.

   a. You notice a coworker creating a dangerous situation by trying to start a drill on bare metal. The drill keeps slipping off to one side. The coworker should:

      (1) Use a more powerful drill.

      (2) Use a smaller, sharper drill bit to get started, then shift to a larger drill bit.

      (3) Use a center punch to mark a starting spot.

   b. You are having difficulty lining up the mating sides of a control cover. A coworker says that you should use a center punch to help align the sides. You should:

      (1) Use a scratch awl because they're made to order for the job.

      (2) Use the center punch, but don't apply excessive pressure on it.

      (3) Use a pin punch because they are small and give you some leeway for alignment.

7. Match types of files with their uses. Place the number beside the type of file in the blank beside the description of its use.

______a. For smoothing metal surfaces; the surface is double-cut to help promote even application

______b. For filing rounded surfaces

______c. For smoothing or enlarging holes in metal; because of the tapered end, they are often called "rat-tail" files

______d. For cleaning up damaged threads or other "fine" work; sometimes called a "saw" file

______e. For working in tight places and "fine" finish work

1. Round
2. Half round
3. Point
4. Flat
5. Three-cornered file

Written Test

8. Solve problems about socket sets and their uses. Circle the number of the item that best solves each of the following problems.

    a. You notice a coworker tightening a bolt with a ratchet and a socket, but you know the bolt needs to be tightened to a specified amount. To solve the problem, the coworker should:

        (1) Use a torque wrench. That's exactly what they're for.

        (2) Use a hinge handle so more torque can be applied.

        (3) Change to a deep socket to afford more torque.

    b. You have run into a bolt that will not come loose with the ratchet handle and socket you are using. You should:

        (1) Hammer on the sides of the bolt as best you can to loosen it.

        (2) Apply some cutting oil to the threads and the bolt, and give it about two minutes to loosen up.

        (3) Switch to a hinge handle so you can apply more torque and not risk damaging a ratchet handle.

9. Solve problems about tubing tools and their uses. Circle the number of the item that best solves each of the following problems.

    a. You notice a coworker has just cut a piece of tubing and begins immediately to flare it. Identify and solve the problem.

        (1) The problem is that the tubing could easily slip, so it should be placed in a flaring block before flaring begins.

        (2) The problem is that cutting may leave burrs in the tubing and they should be removed with a tubing reamer before flaring begins.

        (3) The problem is that the tubing may not be serviceable, so it should be inspected carefully before flaring.

    b. You notice a coworker is about to create a flat spot while trying to bend a piece of tubing by hand. To solve the problem, the coworker should:

        (1) Use a lever-type bender or a bending spring.

        (2) Use only a bending spring.

        (3) Use only a lever-type bender.

Written Test

10. Match threading tools with their uses. Place the number of the tool type in the blank beside the description of its use.

______a. For cutting inside threads in a hole; available in National Fine, National course, and other specifications

______b. A handle used for threading inside threads with a tap

______c. A handle with an adjustable holding device much like the chuck on a drill; used with a tap to drill inside threads, especially smaller size threads

______d. For cutting external threads on round stock; available in many- sizes and specifications

______e. A handle that fits a round stock die to secure it and facilitate turning

______f. An adjustable clamp-type device with sharp-edged rollers that cut into a pipe as they are tightened and turned

______g. For cutting external threads on pipe

______h. A handle designed especially for speeding up the cutting of external pipe threads

1. Hand tap wrench
2. Tap
3. Round stock die
4. T-handle tap wrench
5. Die stock
6. Pipe die stock ratchet
7. Pipe cutter
8. Pipe die

11. Match other hand tools with their uses. Place the number beside the tool type in the blank beside the description of its use.

______a. For removing insulation from electrical wires without damaging the wires

______b. To provide light for dark or poorly-lit work areas; these frequently have an electrical outlet in the handle, but because they are made of small-gauge wire, they should not be used to power appliances such as refrigerators

1. Hack saw
2. Level
3. Nut driver
4. Wire strippers
5. Screw starter

Written Test

_______c. Has a long, flexible spout to reach hard-to-reach places, a cap to prevent oil from dripping out

_______d. For cutting metals in installation and service work, but not recommended for cutting refrigeration tubing because the filings can contaminate a system

_______e. For starting small slot or Phillips-head screws in hard-to-reach places

_______f. A screwdriver-like device with a permanently attached socket for tightening or loosening hex-head nuts and bolts

_______g. For checking the level of AC equipment, floors, and outside unit foundations

_______h. For tightening or loosening socket-type set screws

6. Hex key wrenches
7. Oil can
8. Drop light

12. Complete statements about guidelines for using basic hand tools safely. Circle the material that best completes each of the following statements.

    a. The primary rule for safety using (**any air conditioning tool**) (**any tool**) is to use it only for its intended purpose.

    b. Use only screwdrivers that have undamaged tips; in fact, (**discard**) (**reshape**) screwdrivers with worn tips because they can damage both slot and Phillips-head screws.

    c. Use a hammer when you need to hammer, but do not hammer on a (**screwdriver**) (**pry bar**).

    d. When prying downward with a pry bar, place (**at least one hand**) (**both hands**) flat above the bar so that if the bar slips you will not smash a hand on the floor or a piece of equipment.

    e. Do not hammer with wrenches or on wrenches, and be sure to turn adjustable wrenches in the direction of the adjustable element on the wrench with the stationary part of the wrench (**opposite the side**) (**on the side**) from which force is exerted.

Written Test

f. Do not use pliers in place of a wrench, and in air conditioning work, use pliers with (**nonconductive**) (**insulated**) handles.

g. Keep hammer handles tight, and use the (**proper**) (**smallest**) hammer for the job.

h. Keep points and heads on punches and chisels in good shape; grind chisel heads to keep them from (**mushrooming**) (**becoming uneven**).

i. Keep files (**in a wall rack**) (**out on a work bench**) because if they are kept loose in a drawer, they will become dull.

j. Never use a file without a (**clean filling surface**) (**handle**), and never pry or hammer with a file.

13. Complete statements about guidelines for using other hand tools safely. Circle the material that best completes each of the following statements.

a. Do not use a (**hammer**) (**cheater bar**) or extension pipe on a ratchet or on any handle used with a socket.

b. Use a torque wrench only for torquing nuts to specification and for (**loosening nuts that have been torqued**) (**no other purpose**).

c. Use a few drops of (**machine**) (**cutting**) oil when threading with threading tools, but do not use lubricating oil.

d. Do not keep taps and dies (**on an open table**) (**loose in a drawer**) because it will dull them.

e. Replace the wheels on tubing cutters (**after each half hour of use**) (**when they become dull**).

f. Never run drop light cords over appliance dollies or any kind of (**cart**) (**equipment**).

g. Do not use (**chisels**) (**screw starters**) for screwdrivers.

h. Put a piece of (**tape**) (**cardboard**) over a hacksaw blade to prevent dulling the teeth.

***Permission to duplicate this test is granted.**

Hand Tools
Unit 3

Teacher Supplement 1—Cut External Threads on Selected Stock

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

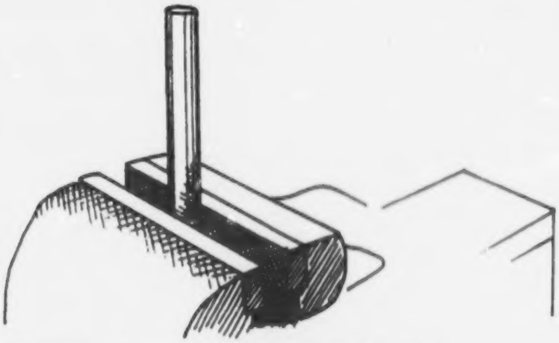
Evaluation criteria	**Rating**
Proper use of die and die stock	______
Threads even and smooth	______
Threads properly cleaned	______

Tools and materials

Die and die stock
Vise
Flat file, wire brush, and oil can
Gloves and safety glasses
Stock as selected by instructor

Procedure

☐ 1. Place the pipe or selected stock in the vise and tighten it firmly.



☐ 2. Chamfer the end of the rod with a file.

☐ 3. Apply cutting oil to the end of the stock.

Teacher Supplement 1

☐ 4. Place the die in the die stock and secure it.

☐ 5. Place die on top of stock with taper facing down.

☐ 6. Start the die straight on the stock as you press down evenly and turn the die.

☐ 7. Stop every other turn and apply cutting oil to the threads and die.

☐ 8. Check the die often to assure that it is running square and even.

☐ 9. Turn the die one turn clockwise then about half a turn counterclockwise to break the chip.

☐ 10. Continue the procedure until the specified amount of threads are cut.

☐ 11. Turn the dies counterclockwise to remove it, and hold the die stock firmly so it won't fall.

☐ 12. Clean the threads with a brush, but do not use compressed air for cleaning.

☐ 13. Have your instructor check your work; clean up area and return tools.

Evaluator's comments: ____

____

____

Hand Tools
Unit 3

Teacher Supplement 2—Cut Internal Threads on Selected Stock

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Proper use of tap and tap wrench	______
Thread hole drilled straight in stock	______
Threads even and smooth	______

Tools and materials

Tap and tap wrench
Drill motor and tap drill
Vise
Oil can
Round rod or stock as selected by instructor
Safety glasses

Procedure

☐ 1. Put on safety glasses.

☐ 2. Place work in vise and select proper tape drill from the following chart:

Sizes	Threads Per Inch	Outside Diameter of Screw	Tap Drill Sizes	Decimal Equivalent of Drill
1	64	073	53	0.0595
2	56	086	50	0.0700
3	48	099	46	0.0810
4	40	112	43	0.0890
5	40	125	38	0.1015
6	32	138	33	0.1130
8	32	164	29	0.1360
10	24	190	25	0.1495
12	24	216	16	0.1770
1/4	20	250	7	0.2010
5/16	18	3125	F	0.2570
3/8	16	375	5/16	0.3125
7/16	14	4375	U	0.3680
1/2	13	500	27/64	0.4219
9/16	12	5625	31/64	0.4843
5/8	11	625	17/32	0.5312
3/4	10	750	21/32	0.6562
7/8	9	875	49/64	0.7656

Teacher Supplement 2

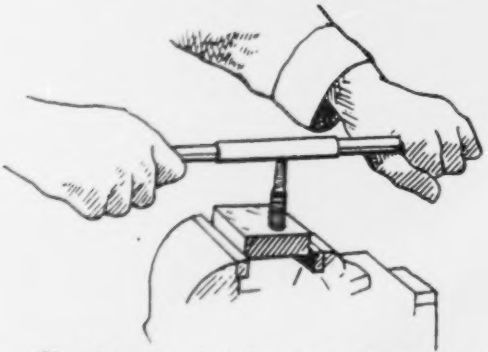
☐ 3. Drill hole to proper size.

☐ 4. Place tap in tap wrench.

☐ 5. Place tap in hole and keep the tap as straight as possible.

☐ 6. Apply cutting oil to the tap.

☐ 7. Press down on the tap wrench with equal pressure on both sides as you make two complete turns with the tap.



☐ 8. Check to see that the tap is straight, and if it is not straight, remove the tap and start over.

☐ 9. Tap the hole by turning the tap wrench half a turn clockwise, then a quarter turn counterclockwise.

☐ 10. Finish the hole and remove the tap by turning the wrench counterclockwise while you hold the tap wrench to keep it from falling.

☐ 11. Have your instructor check your work; clean area and return tools.

Evaluator's comments: ______________________________

____

____

Hand Tools
Unit 3

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Identify Selected Hand Tools and Describe Their Uses Rating ______

Comments: ______________________________

____

Other ______________________________

____

Written Tests: Pretest ______ Posttest ______

Total ______

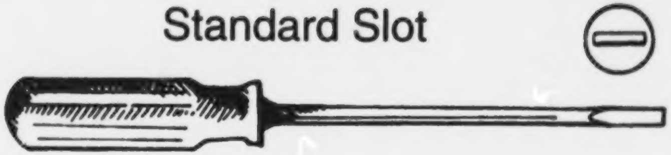
Teacher Signature ______________________ Date ________

Student Signature ______________________ Date ________

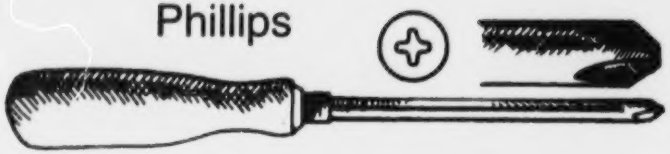
*Permission to duplicate this form is granted.

Screwdrivers

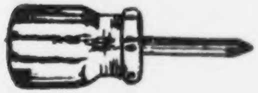
Standard Slot



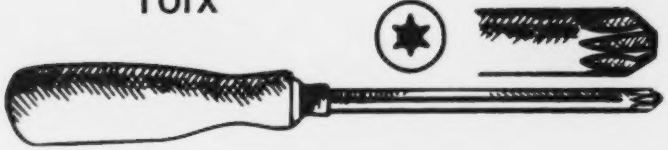
Phillips



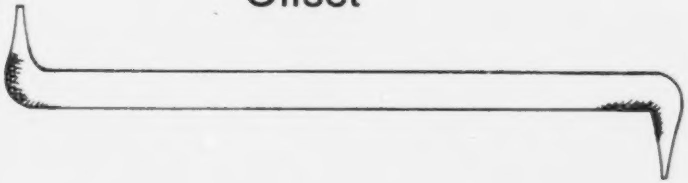
Stubby



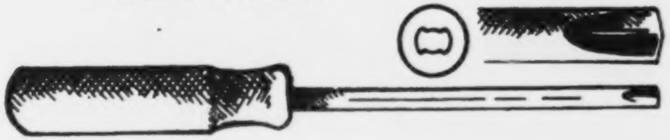
Torx



Offset

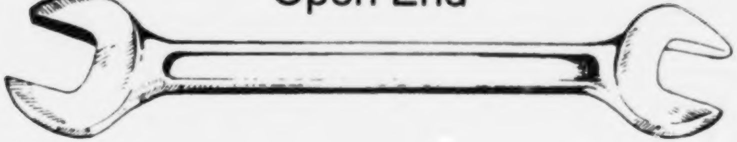


Clutch Head

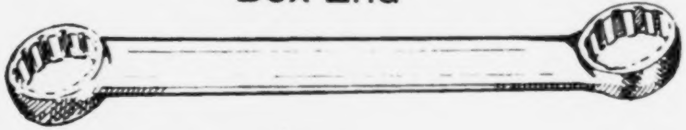


Wrenches

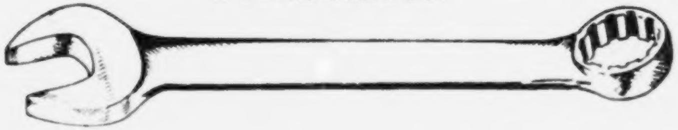
Open End



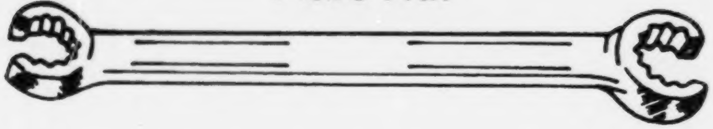
Box End



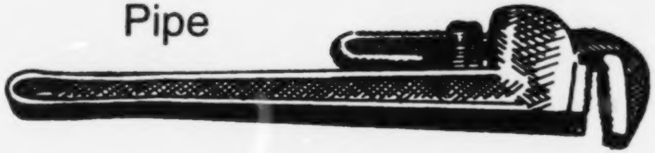
Combination



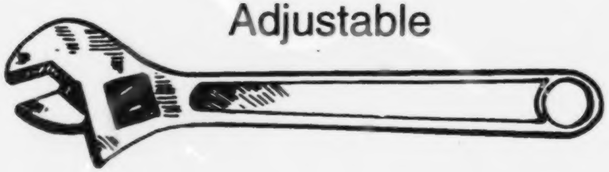
Flare Nut



Pipe



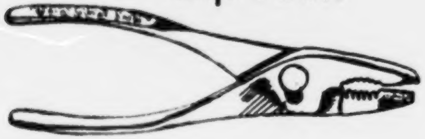
Adjustable



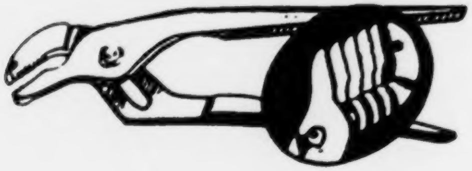
TM 2

Pliers

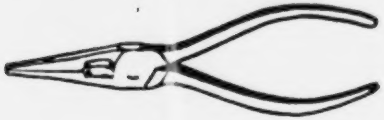
Slip Joint



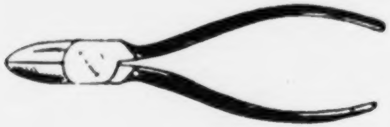
Slip Groove



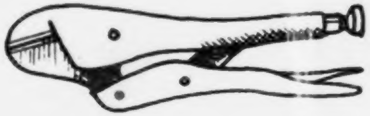
Long Nose



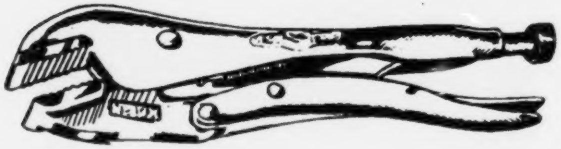
Diagonal Cutters



Pinch-Off

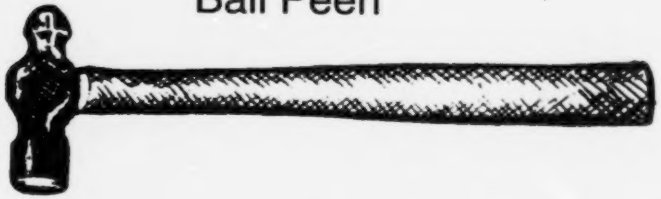


Plier Wrench

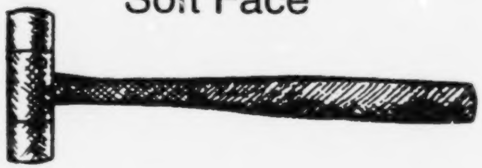


Hammers

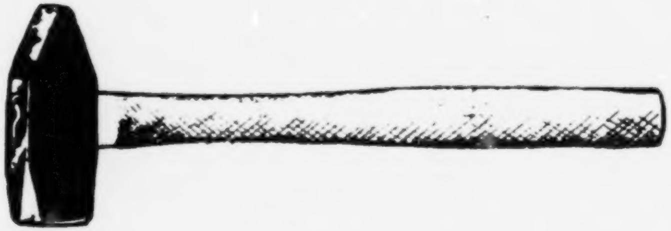
Ball Peen



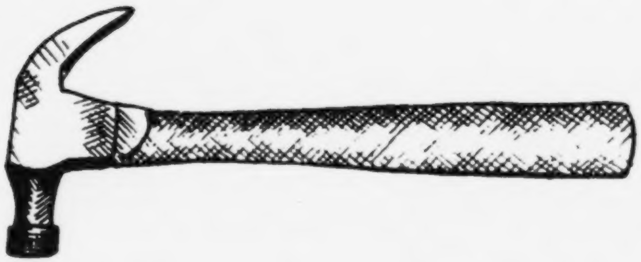
Soft Face



Sledge



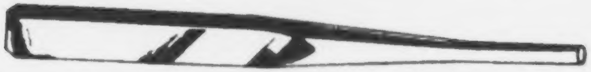
Claw



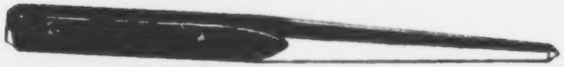
TM 4

Punches, Chisels, and Bars

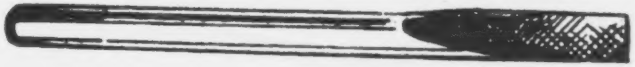
Pin Punch



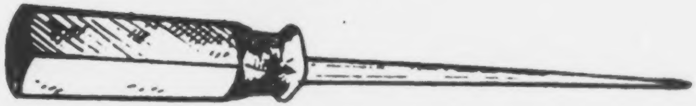
Center Punch



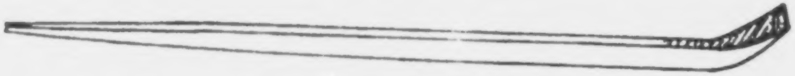
Flat Chisel



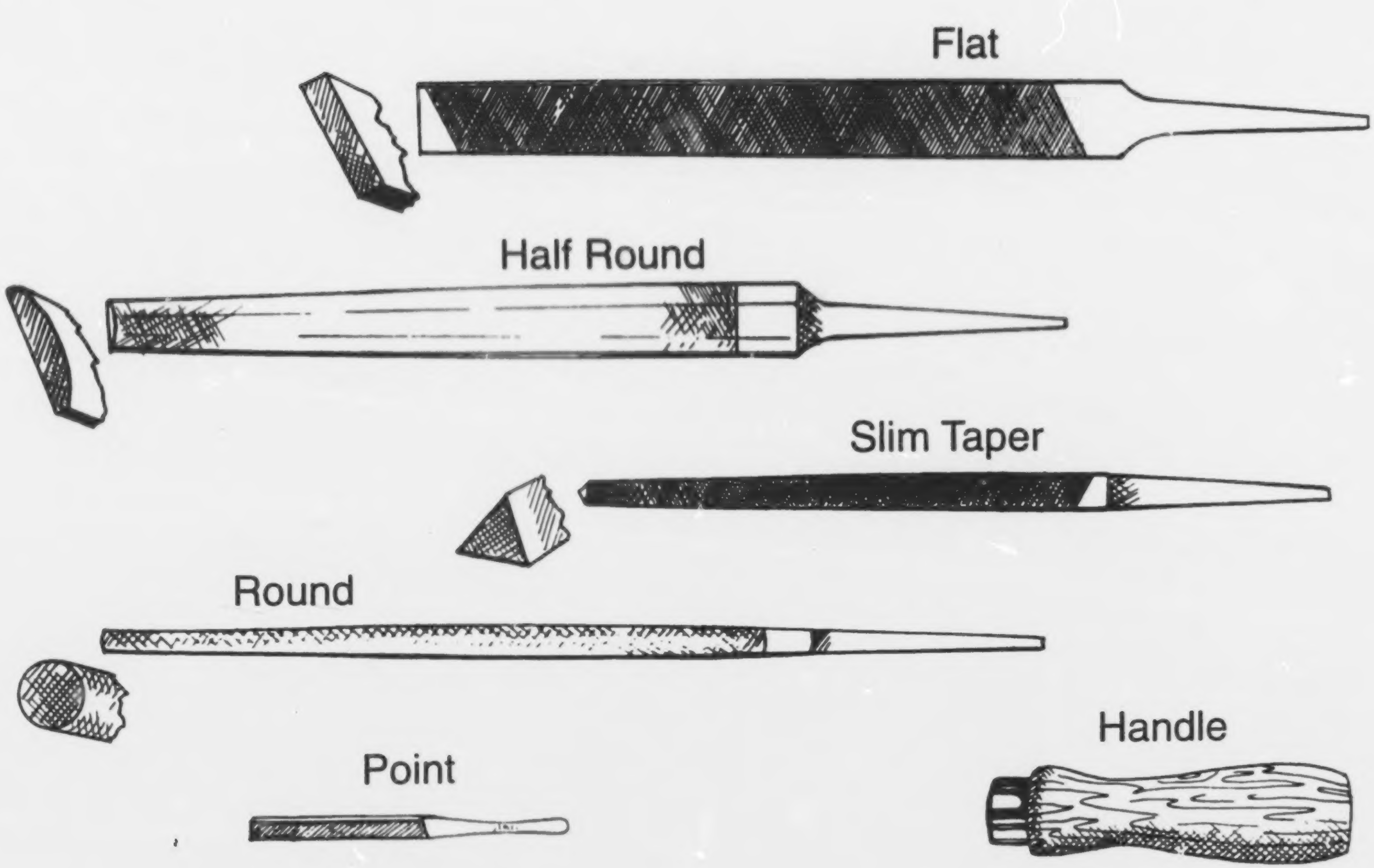
Scratch Awl



Pry Bar



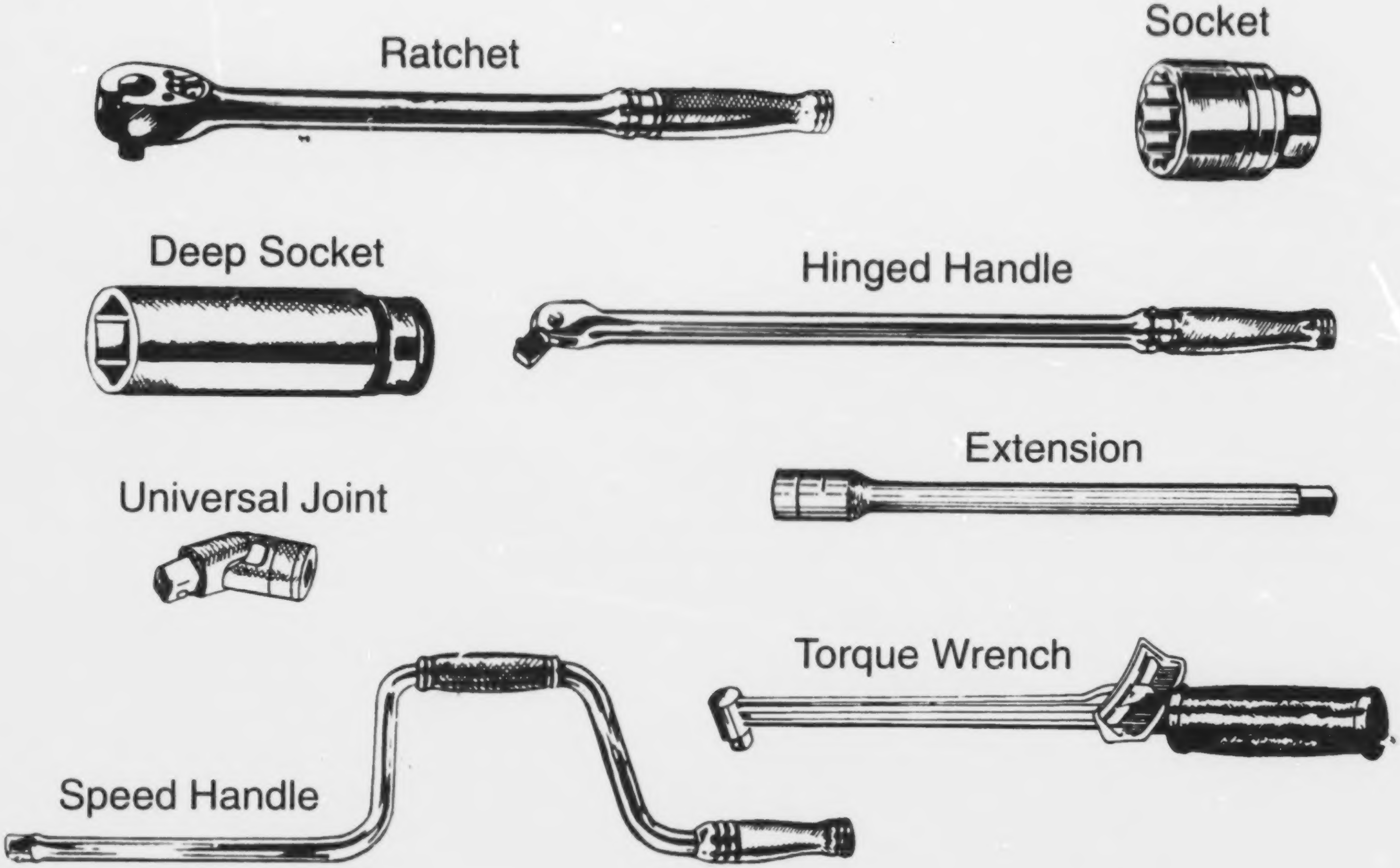
Files


Flat
Half Round
Slim Taper
Round
Point
Handle

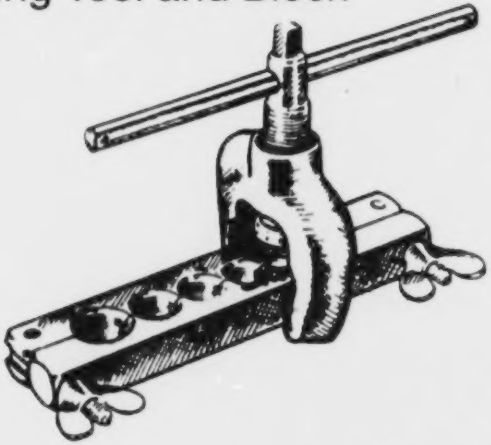
Fundamentals of Air Conditioning and Refrigeration, Unit 3
Teacher Page 33

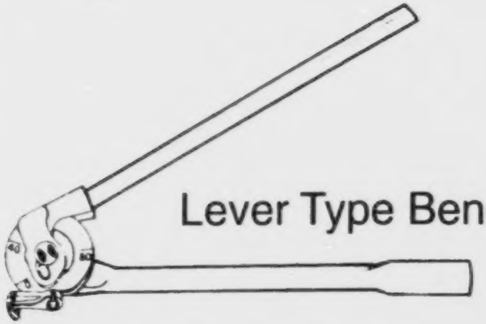
TM 6

Socket Sets

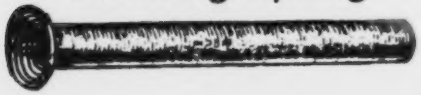

Ratchet
Socket
Deep Socket
Hinged Handle
Universal Joint
Extension
Torque Wrench
Speed Handle

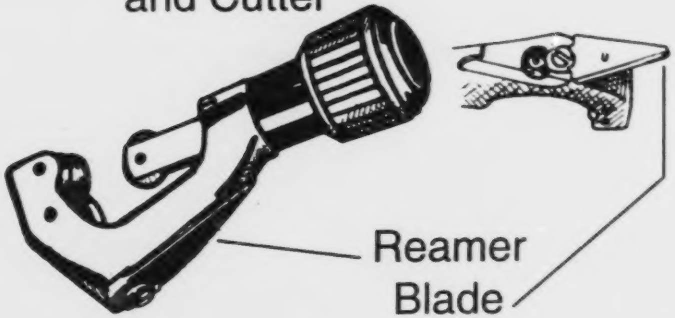
Tubing Tools


Flaring Tool and Block

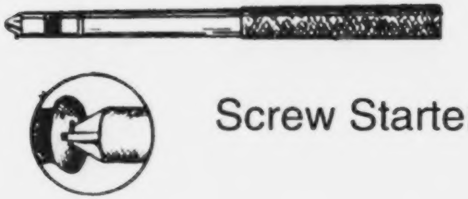

Lever Type Bender

Swage Punch

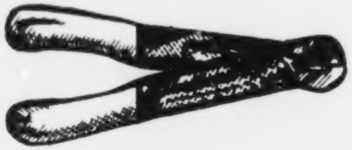

Bending Spring


Tubing Reamer and Cutter

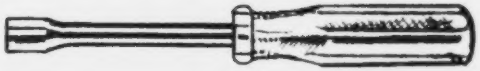
Accessory Hand Tools



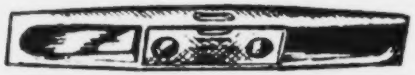
Screw Starter



Wire Strippers



Nut Driver



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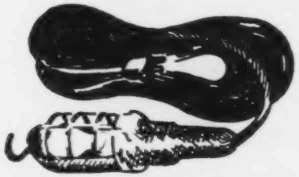
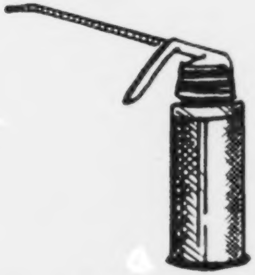
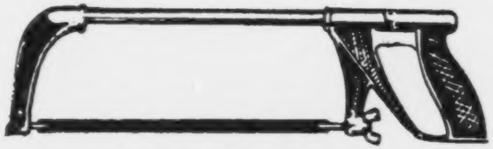


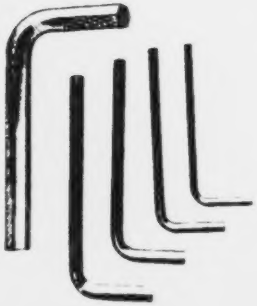
Drop Light



Cutting or
Lubricating Oil



Hack Saw



Hex Key Wrenches

Fundamentals of Air Conditioning and Refrigeration, Unit 3
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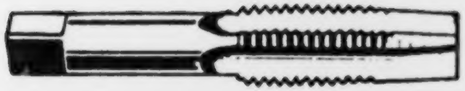
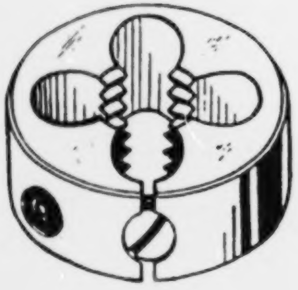
TM 9

Threading Tools

Tap

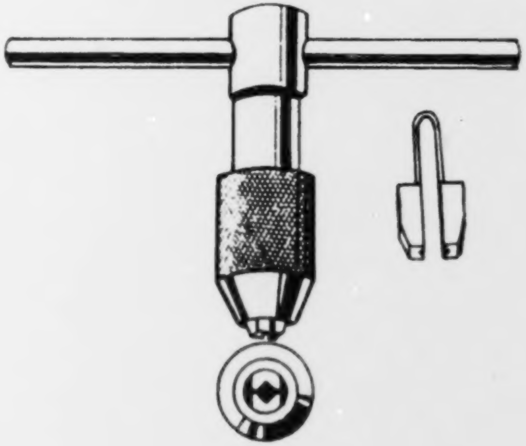


Die

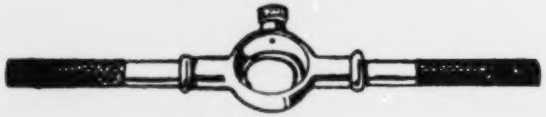


Handles

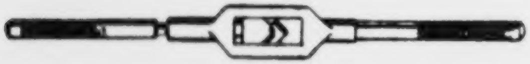
T-Handle Tap Wrench



Die Stock



Hand Tap Wrench



Hand Tools
Unit 3

Information Sheet

1. **Terms and definitions**

   a. **Hand tools** — Tools that are manipulated by hand with a combination of muscle power and operator skill

   b. **National Fine** — A standard established by the Society of Automotive Engineers to identify a type of thread used in precision work

   c. **National Coarse** — A thread type used for general purpose applications

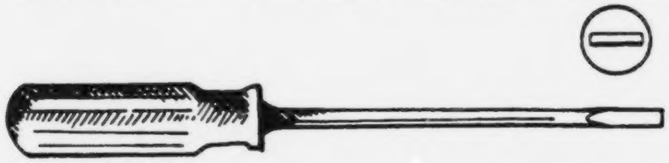
   d. **Powered hand tools** — Highly portable tools that are manipulated by an operator and powered by battery or through an electrical extension cord

   e. **Specialized tool** — A tool designed for specific use or uses

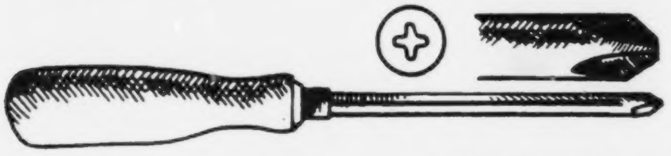
   f. **Swage**— A tube enlarged on one end so that another tube the same size will fit into it

2. **Types of screwdrivers and their uses**

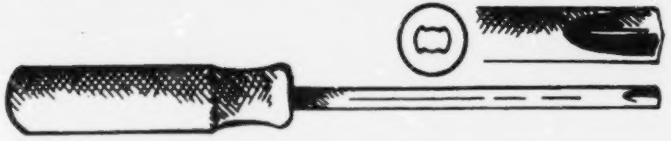
   a. **Standard Slot** — For working with a slot-head bolt or screw



   b. **Phillips** — For working with a Phillips-head bolt or screw

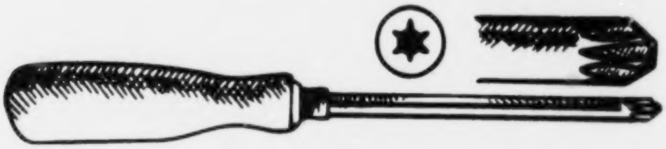


   c. **Clutch head** — For working with a clutch-head bolt or screw

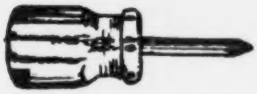


Information Sheet

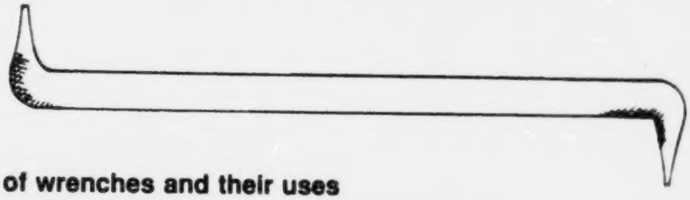
d. **Torx head** — For working with a torx-head bolt or screw



e. **Stubby** — For tightening or loosening in places where a longer blade will not fit

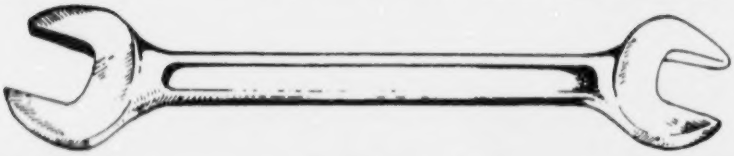


f. **Offset** — For tightening or loosening in extremely close places

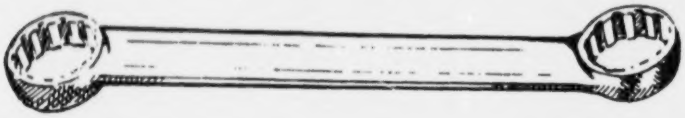


3. **Types of wrenches and their uses**

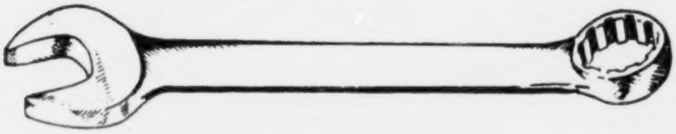
a. **Open end** — For working with hex-head bolts, nuts, or screws



b. **Box end** — A wrench with flat interior surfaces so that it is less likely to slip off when working with hex-head bolts, nuts, or screws when added torque is applied

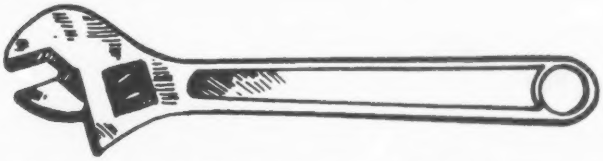


c. **Combination** — A wrench with an open end and a box end for convenience of an operator who may need an open end for speed and a box end for added torque

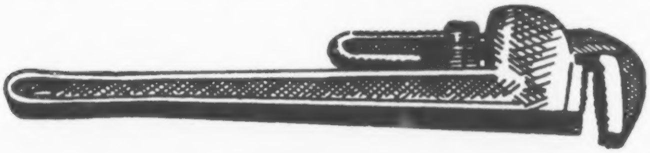


Information Sheet

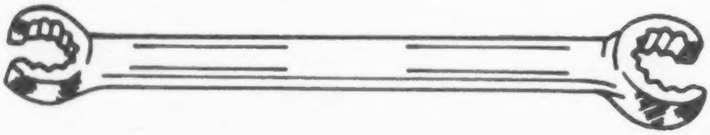
d. **Adjustable open end** — For working with hex-head bolts, nuts, and screws of varied sizes



e. **Pipe** — For working with pipe, pipe fittings, and other rounded surfaces

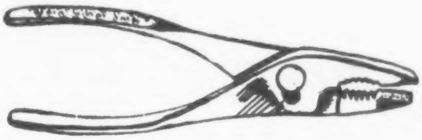


f. **Flare nut** — For working with hex-head nuts, bolts, or screws; the open end permits the wrench to slip over tubing

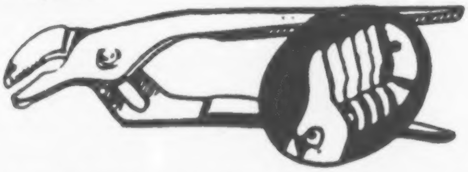


4. **Types of pliers and their uses**

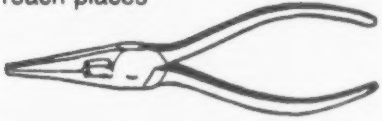
a. **Slip joint** — For holding or turning a part where surface marring is not a problem



b. **Slip groove** — For use on wider surfaces and where more leverage may be required

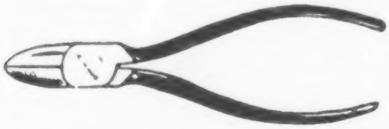


c. **Long nose** — For holding small nuts, screws, or wires, or for reaching hard-to-reach places

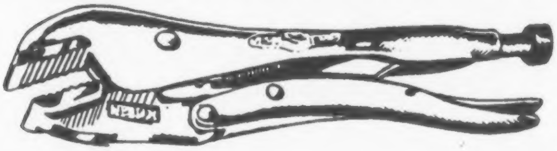


Information Sheet

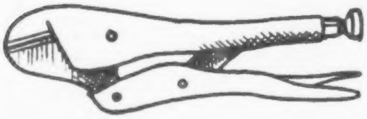
d. **Diagonal cutters** — For cutting wire, and wire only



e. **Plier wrench** (often called a Vise-Grip™) — For working where a tight grip is needed; also locks in place to free operator to use another tool

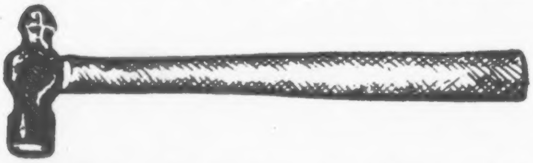


f. **Pinch-off wrench** — A tool designed especially to crimp refrigeration tubing to prevent loss of refrigerant when a tube is being soldered or brazed

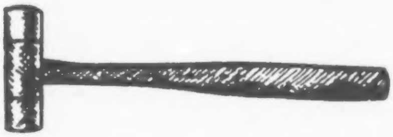


5. **Types of hammers and their uses**

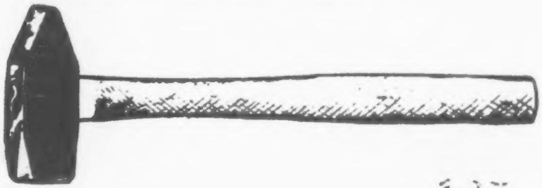
a. **Ball peen** — For hammering metal tools such as punches and chisels



b. **Soft face** — Made of plastic, rubber, rawhide, or material that will not mar or break other tools or materials being hammered

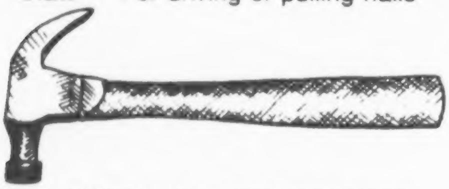


c. **Sledge** —Made with a heavy steel head and a long handle for breaking or pounding with substantial force



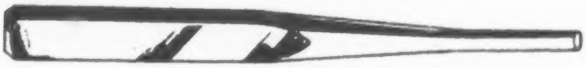
Information Sheet

d. **Claw** — For driving or pulling nails

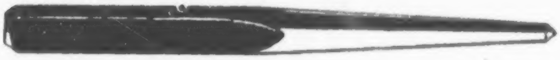


6. **Punches, chisels, bars and their uses**

a. **Pin punch** — For driving both straight and tapered pins into or out of hubs or shafts

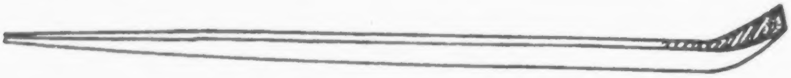


b. **Center punch** — For indenting metal to safely start a drill

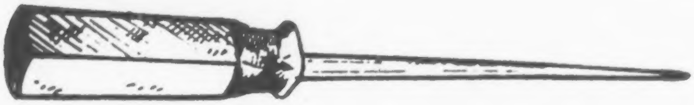


c. **Flat chisel** — For cutting off bolt heads or splitting nuts

d. **Pry bar** — For a variety of jobs, but generally for prying equipment into alignment



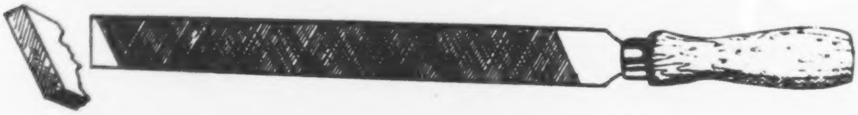
e. **Scratch awl** — For marking on metal, making screw holes in sheet metal, and for aligning screw holes



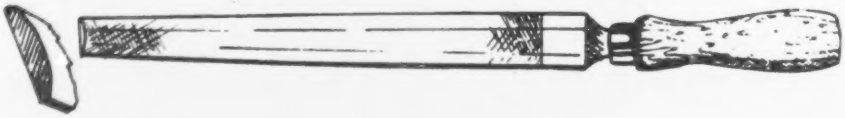
Information Sheet

7. **Types of files and their uses**

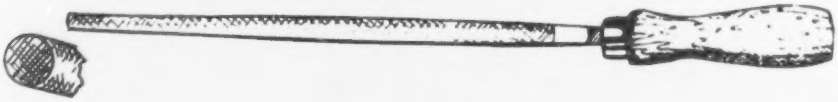
   a. **Flat** — For smoothing metal surfaces; the surface is double-cut to help promote even application



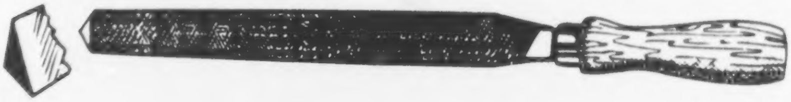
   b. **Half round** — For filing rounded surfaces



   c. **Round** — For smoothing or enlarging holes in metal; because of the tapered end, they are often called "rat-tail" files



   d. **Point** — For cleaning up damaged threads or other "fine" work; sometimes called a "saw" file

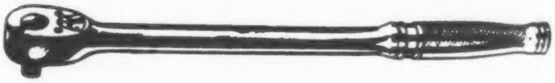


   e. **Three-cornered file** — For working in tight places and "fine" finish work

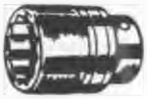
Information Sheet

8. **Socket sets and their uses**

   a. **Ratchet handle** — A drive handle that sockets fit onto so that tightening or loosening motion can be limited to a short back-and-forth motion

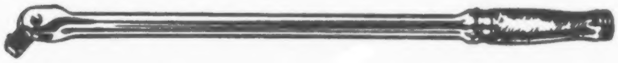


   b. **Socket** — A device that snaps onto a ratchet handle so the device can be used to work on hex-head bolts or nuts

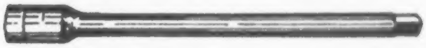


   c. **Deep socket** — A device that snaps onto a ratchet handle so the device can be used to work on hex-head bolts or nuts that are in recessed places that a regular socket cannot reach

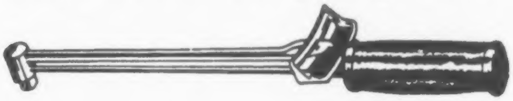
   d. **Hinge handle** — A type of drive handle used when higher torque is needed to tighten or loosen a bolt



   e. **Extension** — A rod that extends from the socket to the handle to extend the socket into hard-to-reach places

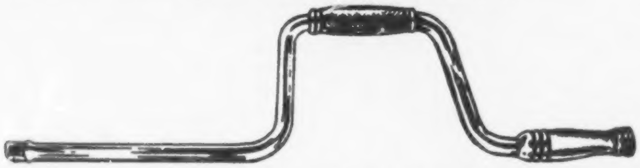


   f. **Torque wrench** — For tightening hex-head bolts and nuts to specified limits

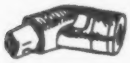


Information Sheet

g. **Speed handle** — A drive handle operated with both hands so that an operator can loosen or tighten nuts and bolts quickly

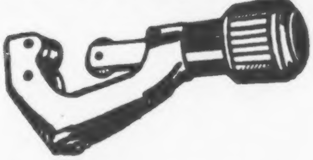


h. **Universal joint** — A device that fits between a handle and a socket to permit the socket to be turned to any one of several angles and to facilitate hard-to-reach nuts and bolts

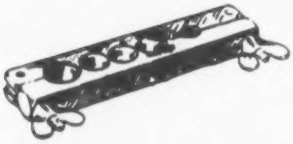


9. **Tubing tools and their uses**

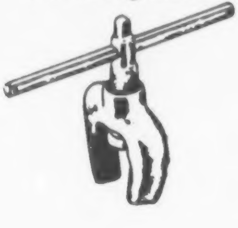
a. **Tubing cutter** — For smoothly cutting tubing with opposing cutting wheels that are slowing tightened by a ratchet-like control as the cutter is turned round and round the tubing



b. **Flaring block** — For holding tubing according to its size so that it can be flared

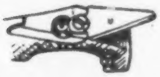


c. **Flaring tool** — For forcing a 45° cone into the end of a copper tube being held in a flaring block

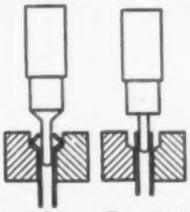


Information Sheet

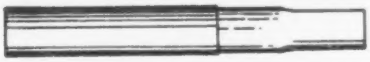
d. **Tubing reamer** — For cleaning burrs off the inside of tubing that has been cut; it is often built into a tubing cutter



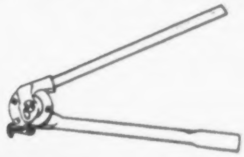
e. **Double flare punch** — For use with a flaring block to bend tubing back and force it down and roll it into the open tubing end to make a tube with double thickness



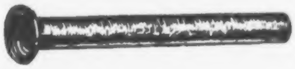
f. **Swage punch** — For enlarging the end of cut tubing so that another tube the same size can be placed into the tubing and soldered



g. **Lever-type bender** — For bending tubing in such a way that the tubing will retain its rounded shape and not flatten out at the point of the bend



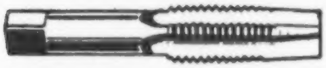
h. **Bending spring** — For placement over the outside of tubing to keep the tubing from collapsing while it is being bent



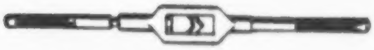
Information Sheet

10. Threading tools and their uses

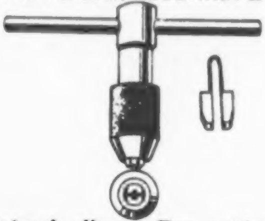
a. **Tap**— For cutting inside threads in a hole; available in National Fine, National course, and other specifications



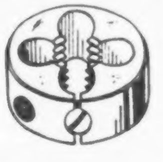
b. **Hand tap wrench** — A handle used for threading inside treads with a tap



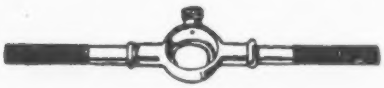
c. **T-handle tap wrench** — A handle with an adjustable holding device much like the chuck on a drill; used with a tap to drill inside threads, especially smaller size threads



d. **Round stock die** — For cutting external threads on round stock; available in many sizes and specifications



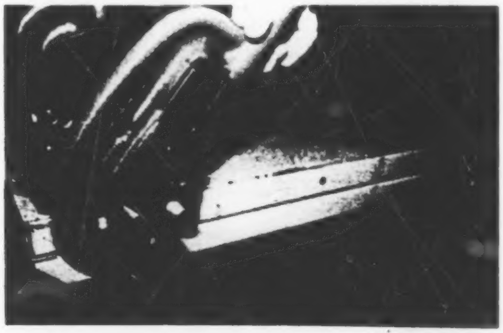
e. **Die stock** — A handle that fits over a round a die to secure it and facilitate turning



Information Sheet

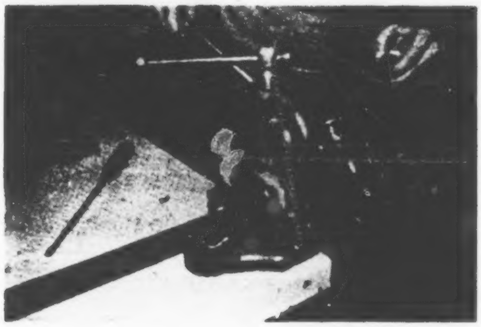
f. **Pipe cutter** — An adjustable clamp-type device with sharp-edged rollers that cut into a pipe as they are tightened and turned

Note: Companies that cut and thread pipe in quantity use electrically-powered automated pipe cutters



g. **Pipe die** — For cutting external threads on pipe

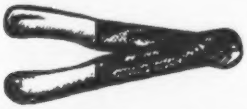
h. **Pipe die stock ratchet** — A handle designed especially for speeding up the cutting of external pipe threads



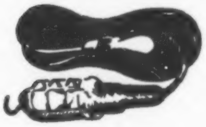
Information Sheet

11. **Other hand tools and their uses**

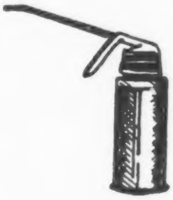
   a. **Wire strippers** — For removing insulation from electrical wires without damaging the wires



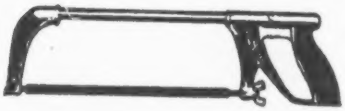
   b. **Drop light** — To provide light for dark or poorly-lit work areas; these frequently have an electrical outlet in the handle, but because they are made of small-gauge wire, they should not be used to power appliances such as refrigerators



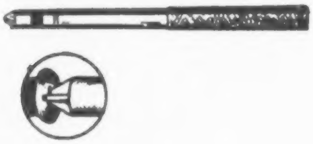
   c. **Oil can** — Has a long, flexible spout to reach hard-to-reach places, a cap to prevent oil from dripping out



   d. **Hack saw** — For cutting metals in installation and service work, but not recommended for cutting refrigeration tubing because the filings can contaminate a system

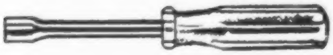


   e. **Screw starter** — For starting small slot or Phillips-head screws in hard-to-reach places

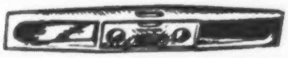


Information Sheet

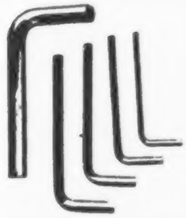
f. **Nut driver** — A screwdriver-like device with a permanently attached socket for tightening or loosening hex-head nuts and bolts



g. **Level** — For checking the level of AC equipment, floors, and outside unit foundations



h. **Hex key wrenches** — For tightening or loosening socket-type set screws

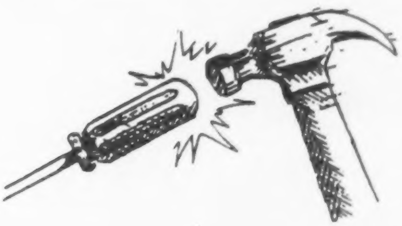


12. Guidelines for using basic hand tools safely

a. The primary rule for safety using any tool is to use it only for its intended purpose.

b. Use only screwdrivers that have undamaged tips; in fact, discard screwdrivers with worn tips because they can damage both slot and Phillips-head screws.

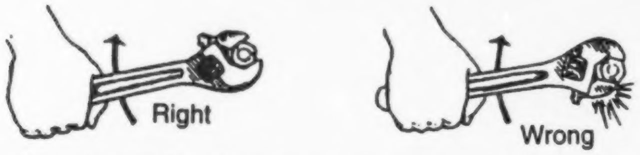
c. Use a hammer when you need to hammer, but do not hammer on a screwdriver.



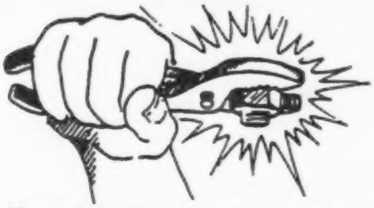
d. When prying downward with a pry bar, place both hands flat above the bar so that if the bar slips you will not smash a hand on the floor or a piece of equipment.

Information Sheet

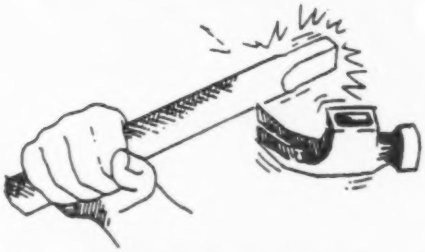
e. Do not hammer with wrenches or on wrenches, and be sure to turn adjustable wrenches in the direction of the adjustable element on the wrench with the stationary part of the wrench on the side from which force is exerted.



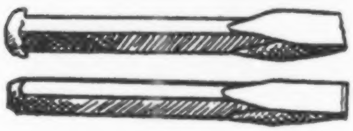
f. Do not use pliers in place of a wrench, and in air conditioning work, use pliers with insulated handles.



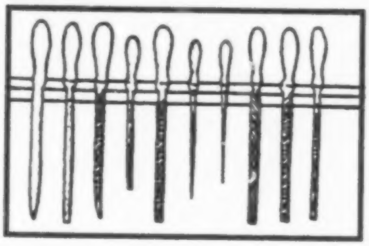
g. Keep hammer handles tight, and use the proper hammer for the job.



h. Keep points and heads on punches and chisels in good shape; grind chisel heads to keep them from mushrooming.



i. Keep files in a wall rack because if they are kept loose in a drawer, they will become dull.

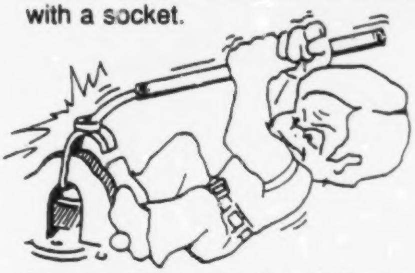


Information Sheet

j. Never use a file without a handle, and never pry or hammer with a file.

13. **Guidelines for using other hand tools safely**

a. Do not use a cheater bar or extension pipe on a ratchet or on any handle used with a socket.



b. Use a torque wrench only for torquing nuts to specification and for no other purpose.

c. Use a few drops of cutting oil when threading with threading tools, but do not use lubricating oil.

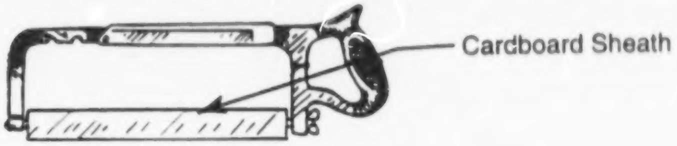
d. Do not keep taps and dies loose in a drawer because it will dull them.

e. Replace the wheels on tubing cutters when they become dull.

f. Never run drop light cords over appliance dollies or any kind of cart.

g. Do not use screw starters for screwdrivers.

h. Put a piece of cardboard over a hacksaw blade to prevent dulling the teeth.



Hand Tools
Unit 3

Assignment Sheet 1—Identify Selected Hand Tools and Describe Their Uses

Name ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of hand tools correctly identified	______
Number of correct usage statements	______

Directions: Your instructor has selected a variety of hand tools and tagged them with numbers. Name each tool selected and briefly describe its intended use.

Tool #1 name: ____________________

Tool #1 use: ____

____

Tool #2 name: ____________________

Tool #2 use: ____

____

Tool #3 name: ____________________

Tool #3 use: ____

____

Tool #4 name: ____________________

Tool #4 use: ____

____

Tool #5 name: ____________________

Tool #5 use: ____

____

Assignment Sheet 1

Tool #6 name: ____________________

Tool #6 use: ____

____

Tool #7 name: ____________________

Tool #7 use: ____

____

Tool #8 name: ____________________

Tool #8 use: ____

____

Tool #9 name: ____________________

Tool #9 use: ____

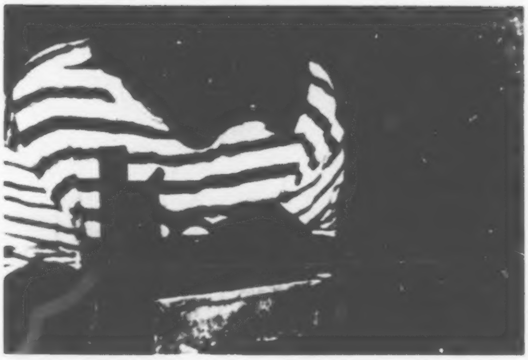
____

Tool #10 name: ____________________

Tool #10 use: ____

____

Note: If your instructor has selected more than ten tools, add them by number to this list.



Special Tools and Measuring
Unit 4

Objective Sheet

Unit Objective

After completing this unit, the student should be able to read a rule and measure distances with a rule. The student should demonstrate this competency by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to special tools and measuring with their correct definitions.
2. Complete statements about guidelines for working with drills and power screwdrivers.
3. Complete statements about the use and care of grinders and vises.
4. Complete statements about the use and care of pullers.
5. Select true statements about caring for drilling tools.
6. Select true statements about the use and care of thermometers.
7. Complete statements about the use and care of hygrometers.
8. Select true statements about the use of sheet metal tools in ACR work.
9. Complete statements about guidelines for measuring distances.
10. Read a rule.
11. Select true statements about metrics in the American workplace.
12. Solve problems about interpolating with match and measuring.
13. Select true statements about decimal equivalents and their applications.

Objective Sheet

14. Complete statements about measuring and converting pressure readings.

15. Complete statements about measuring and converting vacuum readings.

16. Solve problems about measuring and converting weight readings.

17. Complete statements about measuring Btu and Btuh.

18. Measure lines to the nearest quarter, eighth, and sixteenth of an inch. (Assignment Sheet 1)

19. Read a rule. (Assignment Sheet 2)

20. Measure selected items with slide calipers. (Assignment Sheet 3)

21. Grind the head of a chisel or punch. (Job Sheet 1)

22. Sharpen a chisel or screwdriver. (Job Sheet 2)

Special Tools and Measuring
Unit 4

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make a transparency from the transparency master included with this unit. This appears in the teacher edition only and are designed to be used with the objectives 9 and 10.

   TM 1—Units of Measurements

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the assignment sheets and their evaluation criteria; prepare items as indicated for Assignment Sheet 3 to reflect practical applications of slide calipers.

11. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

Suggested Activities

14. Give written test.

15. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Impress upon students the importance of using proper tools for their intended purposes. Stress safety with drilling tools and the need for eye protection at all times. Skill areas: **Learning skills, learning to learn.**

2. Read Assignment Sheet 3 carefully and prepare and tag items for students to measure. Stress the need for being able to measure $^{1}/_{32}$" when the diameter of a shaft must be known to order a replacement fan. Skill areas: **Foundation skills, math.**

3. Review Teacher Supplements 1 and 2. These have been prepared as assignment sheets so you can use them for classroom assignments if you choose. The materials on decimal equivalents actually present the student an opportunity to work in the metric system because that is exactly what decimal equivalents are. Supplement 2 includes an extended conversion chart should you want to have students convert quantities they deal with in everyday life into metric measurements. Skill areas: **Foundation skills, science and math.**

   Note: The following answers for the teacher supplements are provided to save you time if you do reproduce the supplements for student activities.

   Answers to Teacher Supplement 1

a.	.1875	f.	$^{7}/_{16}$
b.	.875	g.	$^{5}/_{16}$
c.	.250	h.	$^{3}/_{8}$
d.	.500	i.	$^{1}/_{8}$
e.	.5625	j.	$^{11}/_{16}$

Suggested Activities

Answers to Teacher Supplement 2

a. 45 kg
b. 1.125 kg
c. 1.90 liters
d. 14.25 liters
e. .245 ounces
f. 3.18 quarts
g. 24.84 mpg

4. Teacher Supplement 3 shows students how to use a ¼″ architect's rule. Although this is an optional student skill, students will find it handy for measuring items in the job sheets in Unit 5, and for the brazing project in Unit 9. Skill areas: **Foundation skills, math.**

Resources Used in Developing This Unit

1. Jones, Leonard and Otto Morse. *Sheet Metal Basics.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1983.

2. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

3. *Paxton/Patterson Graves-Humphreys Catalog 93.* Chicago, IL: Paxton/Patterson, 1993.

4. "Refrigerant Recovery Tanks", pamphlet. Columbus, OH: Worthington Cylinder Corporation, 1994.

5. *The Air Conditioning, heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1993.

6. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Suggested Activities

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Special Tools and Measuring
Unit 4

Answers to Assignment Sheets

Assignment Sheet 1

1. a. $3\frac{1}{4}''$
   b. $4\frac{1}{2}''$
   c. $1''$
   d. $2''$

2. a. $4\frac{3}{4}''$
   b. $2\frac{1}{2}''$
   c. $3\frac{5}{8}''$
   d. $4\frac{1}{4}''$

3. a. $4\frac{1}{16}''$
   b. $1\frac{1}{16}''$
   c. $2\frac{5}{8}''$
   d. $3\frac{5}{16}''$

Assignment Sheet 2

1. $\frac{1}{2}''$
2. $\frac{3}{4}''$
3. $\frac{7}{8}''$
4. $1\frac{1}{8}''$
5. $1\frac{5}{16}''$
6. $1\frac{9}{16}''$
7. $1\ \frac{3}{4}''$
8. $2''$
9. $2\frac{3}{16}''$
10. $2\frac{7}{16}''$
11. $2\frac{5}{8}''$
12. $2\frac{7}{8}''$
13. $3\frac{1}{16}''$
14. $3\frac{1}{4}''$
15. $3\frac{7}{16}''$
16. $3\frac{5}{8}''$
17. $3\ \frac{7}{8}''$
18. $4''$
19. $4\frac{3}{16}''$
20. $4\frac{5}{16}''$
21. $4\frac{5}{8}''$
22. $4\frac{7}{8}''$
23. $5\frac{1}{16}''$
24. $5\frac{3}{16}''$
25. $5\frac{3}{8}''$
26. $5\frac{7}{16}''$
27. $5\frac{5}{8}''$
28. $5\ \frac{3}{4}''$
29. $6''$
30. $6\frac{1}{8}''$

Assignment Sheet 3

Materials selected by instructor; evaluate according to criteria in assignment sheet.

Special Tools and Measuring
Unit 4

Answers to Written Test

1. a. 5
   b. 4
   c. 7
   d. 3
   e. 1
   f. 6
   g. 2

2. a. limited work space
   b. portability
   c. torque
   d. recharged
   e. masonry
   f. a keyless, a keyless
   g. wastes time on the job

3. a. safety shield clean and in place
   b. Dress
   c. dry
   d. loosen
   e. accidentally bend
   f. hammer
   g. pose a safety hazard

4. a. bearings, gears
   b. pointed
   c. shaft

5. a, b, c, d, e, g

6. a, c, d, f, g, i, j

7. a. relative humidity
   b. "wet bulb"
   c. human hair
   d. circular
   e. each time a humidity test is made

8. a, c, d, e, f, g, h, j

Answers to Written Test

9. a. fractions
    b. millimeters
    c. circumference
    d. retractable
    e. long
    f. short distances
    g. scratch awl
    h. shaft diameters

10. a. $\frac{1}{2}''$
    b. $\frac{2}{4}''$
    c. One and one-sixteenth inch
    d. $1\frac{3}{16}''$
    e. $1\frac{3}{8}''$

11. a, b, c, d

12. a. (3)
    b. (2)

13. b, c

14. a. 14.7
    b. presence
    c. add
    d. metric
    e. 7.0
    f. interpolate

15. a. deepest
    b. removing pressure from
    c. microns
    d. centimeters
    e. 2.54
    f. 2.54

16. a. Fahrenheit (°F)
    b. 32
    c. multiplying
    d. 32, 32

17. a. (1)
    b. (2)

Answers to Written Test

18. a. gain
    b. loss
    c. specific heat
    d. 10
    e. metric
    f. loads
    g. performance

Special Tools and Measuring
Unit 4

Written Test

Name ________________ ________________ Date ________________ Score ______

1. Match the terms on the right with their correct descriptions.

______a. A system of measurements based on units that vary by application such as pounds and ounces for weight and inches and feet for length

______b. An instrument that senses and measures humidity

______c. Estimating unknown values by referencing known values

______d. A U-shaped tube filled with mercury or water with a graduated scale for reading the pressure of gases

______e. A system of measurements based on units of ten; also known as the International System of Units because of its adoption by the international scientific community

______f. Pounds per square inch absolute, a pressure reading where zero does not include the 14.7 pounds per square inch exerted by atmospheric pressure

______g. Pounds per square inch gauge, a pressure reading where zero does include the 14.7 pounds per square inch exerted by atmospheric pressure, and often abbreviated to psi

1. Metric system
2. psig
3. Manometer
4. Hygrometer
5. English system
6. psia
7. Interpolating

Written Test

2. Complete statements about guidelines for working with drills and power screwdrivers. Circle the material that best completes each of the following statements.

   a. Electric-powered hand drills are configured for drilling straight into wood or metal, and some are configured with a 90° offset so they can be used in areas with (**limited work space**) (**for high-torque drills**).

   b. Battery-powered screwdrivers can also be used for drilling, and their light weight, (**small size**) (**portability**), and versatility make them popular tools at the jobsite.

   c. Several battery-powered screwdrivers have adjustable (**torque**) (**bit holders**) so they can be used with a drill bit, or with power bits for several types of screwdrivers, and bits for nut drivers that are essential for working with sheet metal screws.

   d. Many battery-powered screwdrivers have extra battery packs so a charged pack can be quickly installed and work can continue while a dead battery is being (**replaced**) (**recharged**).

   e. Keep an assortment of drill bits for metal, wood, and (**masonry**) (**plastics**).

   f. Some drills and screwdrivers have (**an attached**) (**a keyless**) chuck because it eliminates the need for a chuck key which is very easy to lose; older drills can be modified for (**an attached**) (**a keyless**) chuck.

   g. If a drill has a chuck key, attach it to the drill; chuck keys vanish into thin air for no reason at all, and hunting an elusive chuck key (**wastes time on the job**) (**doesn't mean you'll find it**).

3. Complete statements about the use and care of grinders, vises, and presses. Circle the material that best completes each of the following statements.

   a. Keep the tool rest on a bench grinder tight, and keep the (**safety shield clean and in place**) (**grinding wheel secure**).

   b. (**Change**) (**Dress**) the grinding wheel on a bench grinder when a grinding job takes too long or the wheel becomes laden with fragments from previous jobs.

   c. Keep bench vises and pipe vises clean, and lightly oil the clamping screw if it appears to be (**worn**) (**dry**).

   d. Do not hammer on the jaws of any vise, and do not overtighten a vise or hammer on the tightening handle except to (**tighten**) (**loosen**) the handle with a light tap of a soft-face mallet.

Written Test

e. Use bench vises for holding objects in place, but use pipe vises only for securing pipe or conduit, and remember that conduit is easy to (**accidentally bend**) (**accidentally scratch**) in a vise.

f. Keep drill presses clean, keep guards in place, and use the press only for drilling; do not (**file**) (**hammer**) or cut on a drill press.

g. Sweep up metal shavings that collect on or around a drill press because the sharp edges of shavings (**pose a safety hazard**) (**pose a system problem**) both in the shop and on a worksite.

4. Complete statements about the use and care of pullers. Circle the material that best completes each of the following statements.

a. A wheel puller is used for removing pulleys and (**sheaves**) (**bearings**) from motor shafts, and a gear puller is used for removing pulleys and (**sheaves**) (**gears**) from motor shafts.

b. Oil the threaded shaft on pullers at needed intervals, keep the tips (**aligned**) (**pointed**) so they will hold tightly, and do not drop a puller because they have sensitive balance.

c. A fan blade puller is used to remove the fan from a (**system**) (**shaft**), and the shaft will usually require light oiling to facilitate removing the blade.

5. Select true statements about caring for drilling tools: Place an "X" beside each true statement.

_______a. Keep motor-cooling openings on all power equipment clean and open.

_______b. Check for cord breaks on electric-powered drills, never pick up a drill by the cord, and never try to unplug a drill by jerking on the cord; grasp the cord at the plug.

_______c. Do not overload a drill, and do not drop a drill.

_______d. Keep drill bits stored in a box, and never force a drill bit.

_______e. Use twist drills for metal, wood drills for wood, and never use a wood or masonry drill for metal.

_______f. Apply cutting oil when drilling thicker metals, and use special masonry oil for cooling a masonry bit cutting concrete or stone.

_______g. Keep power bits for power screwdrivers in order in a closed case; if they are thrown into an open tool box, they become difficult to find.

Written Test

6. Select true statements about the use and care of thermometers. Place an "X" beside each true statement.

______a. Portable pocket thermometers clip into a shirt pocket and are handy for temperature measurement at almost any point in a system.

______b. Pocket thermometers are also available in Fahrenheit and Celsius scales, and some models have Kelvin scales on them.

______c. Remote bulb thermometers are especially designed to provide a readout for temperature sensed in a remote area that a technician cannot physically access.

______d. Pocket and remote bulb thermometers are available in several temperature ranges, but the –10° to +100° range is the type most often used.

______e. The thermal electric thermometer is designed for measuring a broad range of temperatures, from –20° to +200°, and some types have multiple leads that permit the measurement of more than one temperature.

______f. The digital thermometer is the easiest of all thermometers to read, and is preferred where an extremely accurate temperature reading is required, and they are available in several configurations ranging from pocket types to models with remote sensing devices.

______g. Flue and stack thermometers are designed for measuring temperatures in furnace flues and stacks, and their range is usually from 200°F to as much as 1000°F.

______h. Recording thermometers keep track of temperature over months and years.

______i. Wind-up manual recording thermometers often record on a circular chart, electric models usually record on a strip chart, and computer-controlled models print out a temperature chart at programmed intervals.

______j. Never drop a thermometer, keep them clean, check batteries often, if they are battery-operated, and use thermometers for their intended temperature ranges.

Written Test

7. Complete statements about use and care of hygrometers. Circle the material that best completes each of the following statements.

   a. Hygrometers are a general class of instruments that help ACR technicians measure (**relative humidity**) (**dew point**) outside, in a room, or in any air-conditioned space.

   b. The sling psychrometer is a portable hygrometer with a wick that a technician wets with distilled water; the water evaporates when the psychrometer is whirled around and provides a (**"wet bulb"**) (**enthalpy**) or humidity reading.

   c. A dial-type hygrometer is built with a highly sensitive (**human hair**) (**carbon wire**) that responds to humidity changes and provides a readout.

   d. A humidity recorder keeps track of humidity changes over a period of time by tracking the changes on a (**strip**) (**circular**) chart.

   e. Keep all hygrometers clean, keep sling psychrometers in a box when not in use, use a fresh wick (**each week**) (**each time a humidity test is made**), and never drop one of these carefully calibrated instruments.

8. Select true statements about the use and care of sheet metal tools in ACR work. Place an "X" beside each true statement.

   ______a. Use a knockout cutter for making holes in sheet metal, especially for holes in cabinets that will be used for electrical conduit and refrigerant lines.

   ______b. Do use a knockout cutter on thick sheet metal, but hit it extra hard.

   ______c. Use combination pattern snips for general sheet metal cutting; they are designed to make metal curl up out of the way when making circular cuts.

   ______d. Use a hand notcher for cutting uniform edges in sheet metal.

   ______e. Use a hand seamer when forming a seam on a piece of sheet metal.

   ______f. Use a riveter for joining pieces of sheet metal together.

   ______g. Use a riveting hammer to form sheet metal; the hammer edges are beveled to prevent marking the sheet metal.

   ______h. Use a hand crimper fro shaping the end of flue or other pipe that has to be fitted together.

Written Test

______i. Use regular snips for cutting sheet metal in a right-handed or left-handed direction.

______j. Use double-cutting snips for cutting when both pieces of sheet metal must lie flat.

9. Complete statements about guidelines for measuring distances. Circle the material that best completes each of the following statements.

   a. Standard measuring means using a fractional rule to measure in yards, feet, inches, or (**fractions**) (**quarters**) of an inch.

   b. Metric measuring means using a metric rule to measure in meters, decimeters, centimeters, or (**millimeters**) (**ampmeters**).

   c. Measuring in ACR work often means measuring straight distances, but can require measuring through the center of a circular object to determine diameter, or around a circular object, such as ductwork, to determine (**circumference**) (**thickness**).

   d. ACR technicians mostly use (**retractable**) (**folding**) tapes because they're highly portable, handy because they snap right over a technician's belt and versatile because most can measure up to several feet in increments down to $\frac{1}{16}$ of an inch.

   e. Carpenter's roll-up tapes are used for measuring (**long**) (**irregular**) distances, and folding carpenter's rules are also common around a jobsite because they are rigid and can be used for measuring upward where a retractable tape would bend.

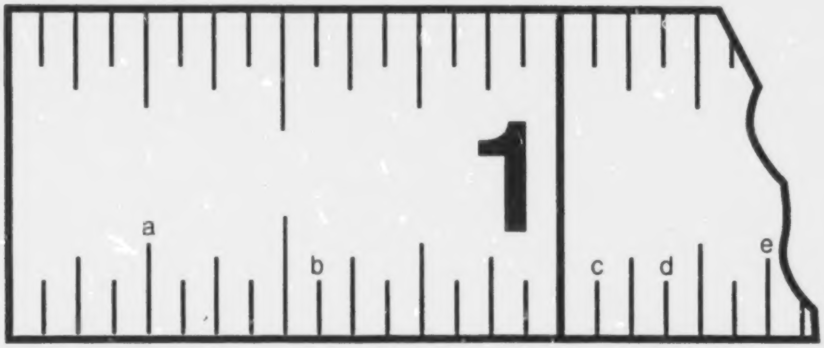
   f. Combination squares are handy for measuring (**short distances**) (**critical distances**) and for checking the square of cabinets and wooden framing.

   g. Tempered steel rules, especially circumference rules, are used for sheet metal layout because a (**marking pencil**) (**scratch awl**) slides easily along the tempered edge.

   h. Slide calipers are used for critical measurements because they will measure in increments to $\frac{1}{32}$" or even to $\frac{1}{64}$"; calipers are used to measure (**shaft diameters**) (**blade lengths**) when replacement fans are ordered.

Written Test

10. Read a rule. Examine the rule in the following illustration and indicate how the measurement should be written or called out.



a. Written: ______________________________

b. Written: ______________________________

c. Called out: ______________________________

d. Written: ______________________________

e. Written: ______________________________

11. Select true statements about metrics in the American workplace. Place an "X" beside each true statement.

______a. Most of the countries not on the metric system started converting to the metric system in the early 1970s, but although metrics are the streamlined, easy way to measure anything, America has never officially "gone metric."

______b. But official or not, the metric system is working in America and it is here to stay because more than ever before, American industries are competing in a global market, and that market measures in metrics.

______c. Being aware of metrics is almost as important as using metrics, and this is especially true in the ACR industry where the rush to manufacture replacement refrigerants for R-11, R-12, and R-502 have inspired an influx of refrigerants that are measured in kg (kilograms) instead of lbs. (pounds) and where pressures are measured in kPa (kilopascals) instead of psi (pounds per square inch).

Written Test

______d. American industries that have had to keep overseas metric inventory and American inventory based on the English system of measurement are losing a great deal of money by working with two systems, and changes are underway in all industries to solve the problem by "going metric."

______e. For ACR technicians, the switch to metric measuring will be difficult, but it has to be done.

12. Solve problems about interpolating with math and measurement. Circle the number of the statement that best solves each of the following problems.

    a. You are working with a pressure/temperature chart that has a few temperature and pressure relationships missing. When you start interpolating an answer for the p/t relationships you need, a fellow worker tells you it won't work because you're only guessing. The problem is, how right is your fellow worker?

        (1) Probably right because p/t relationships cannot be interpolated from a chart.

        (2) Probably wrong because an intelligent guess usually comes close enough to serve the purpose.

        (3) Definitely wrong because an intelligent reference to known values should give an almost precise answer and can save time.

    b. You know that a refrigerant cylinder can only be filled to 80% of its water capacity which is 26.2 lbs. How can you determine what the 80% figure would be without stopping to figure it out with pencil and paper?

        (1) Use 20 lbs. as a figure that you know will be safe.

        (2) Make a quick interpolation; 50% or half of 26.2 is 13.1, and 10% would be 2.6, so by adding the 13.1 and 3× 2 (6), you get 19.1, and then add 3× .6 (1.8) to get 20.9 lbs.

        (3) Just do it in your head because 26.2 × .80 is simple to figure.

Written Test

13. Select true statements about decimal equivalents and their applications. Place an "X" beside each true statement.

______a. Adding, subtracting, and multiplying fractions is a time-consuming chore that requires several steps and employs some rules that are often forgotten even though many people work with fractions on the job.

______b. A decimal equivalent chart converts fractions into decimals so they can be added, multiplied, subtracted, or divided with greater speed and less chance for error.

______c. A decimal equivalent chart is a handy tool for technicians who work with rules or tapes that have fractions used to measure everything from bolt sizes to the length of refrigerant lines.

14. Complete statements about measuring and converting pressure readings. Circle the material that best completes each of the following statements.

a. ACR gauges measure pressure in psig, pounds per square inch gauge, usually shortened to psi to indicate that the gauge is compensating for (**14.7**) (**20**) pounds of atmospheric pressure.

b. In some ACR service literature it is fairly common to run into references to psia; this means a pressure reading with the (**absence**) (**presence**) of atmospheric pressure as a reference point and is called psia, pounds per inch absolute.

c. Readings for psia pressures sometimes appear in ACR service literature, so when you confront a psia reading and need to convert it to psig, (**subtract**) (**add**) 14.7.

d. As America becomes more and more a part of a global marketplace, more and more pressure readings are stated in kilopascals, the (**English**) (**metric**) reference for pressure.

e. The kilopascal is noted as kPa, and 1 kPa = .143 psi while 1 psi = (**7.0**) (**9.0**) kPa.

f. Converting from psi to kPa or from kPa to psi can be accomplished with some educated guessing if you reference known pressures and then (**interpolate**) (**multiply**).

Written Test

15. Complete statements about measuring and converting vacuum readings. Circle the material that best completes each of the following statements.

    a. Measuring a vacuum means measuring any pressure less than atmospheric pressure; zero on the psia scale indicates a perfect vacuum or the (**deepest**) (**largest**) vacuum that can be measured.

    b. A vacuum is measured by (**applying pressure to**) (**removing pressure from**) liquids enclosed in a column, and several liquids, including water, are used, but Mercury has proved to be the best liquid for the application, and vacuums are almost always measured in inches of Mercury, noted as in Hg.

    c. Beyond certain levels, vacuums are measured in (**centimeters**) (**microns**) because the measurements, at certain levels, are more accurate than can be obtained with gauge readings.

    d. The compound gauge on a technician's manifold gauge set is designed especially to measure vacuums in inches of Mercury, but some literature expresses vacuums metrically, and this means they have to be measured in (**centimeters**) (**meters**) of mercury, usually using a mercury manometer.

    e. Centimeter is noted as cm, and 1 cm = 0.4 in. while 1 in. = (**2.54**) (**3.00**) cm.

    f. Converting from cm to in. or in. to cm is best accomplished by using the 0.4 in. or (**2.54**) (**3.00**) cm conversion factors.

16. Complete statements about measuring and converting temperature readings. Circle the material that best completes each of the following statements.

    a. Temperature readings in ACR service are mostly taken in degrees (**Fahrenheit (°F)**) (**Kelvin (K°)**), but Celsius readings are often referenced, and technicians need to be able to convert from °F to °C.

    b. Because technicians may confront service literature with references in °C, converting C into F will probably be a more common need than converting F into C, so, the formula for converting C to F is $\frac{9}{5}$°C + (**50**) (**32**) = °F.

    c. The formula in item b provides a good example of how a decimal equivalent can be put to good use because finding $\frac{9}{5}$ of a Celsius reading requires dividing a fraction when the same answer can be obtained by (**dividing**) (**multiplying**) the decimal equivalent of a fraction.

    d. In cases where °F have to be converted to °C, the formula is $\frac{5}{9}$ × the degrees in F minus (**50**) (**32**), expressed as $\frac{5}{9}$ (°F – (**32**) (**50**)).

Written Test

17. Solve problems about measuring and converting weight readings. Circle the number by the statements that best solves each of the following problems.

    a. You've been instructed to recover refrigerant from a system and you have to place the recovered refrigerant in a refillable cylinder. Since the cylinder has no automatic fill switch, you will have to somehow determine how much refrigerant you can allow into the cylinder. To solve the problem, you should:

        (1) Look at the water capacity stamped on the cylinder, subtract 20% from that figure, and limit the weight of your recovered refrigerant to that amount.

        (2) Put no more than 20 lbs. of refrigerant into the cylinder because that is below the 80% fill limit of any cylinder you might be using.

        (3) Be smart enough to ask another technician how much refrigerant they usually put into a cylinder that size.

    b. You are refilling a cylinder that you know will be stored for a short while in an area where the temperature could get close to 130°F. How will this dictate how much refrigerant you put into the recovery cylinder?

        (1) Since the cylinder will be stored under elevated heat conditions for only a short time, stick with the regular 80% fill limit.

        (2) Stay at least a little below the 80% fill limit.

        (3) Take no changes, reduce the fill limit to 65% to be certain.

18. Complete statements about measuring Btu and Btuh. Circle the material that best completes each of the following statements.

    a. A Btu is a British thermal unit, the industry standard for measuring heat gain and heat loss; when expressing heat (**loss**) (**gain**), a Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

    b. When expressing heat (**gain**) (**loss**), a Btu is the amount of heat that must be removed from 1 pound of water to lower the water 1 degree Fahrenheit.

    c. The Btu formula is based on the specific heat of water; to apply the formula to other liquids or substances requires the (**specific heat**) (**density**) of the substance.

Written Test

d. In application, raising the temperature of water 10°F would 10 times the Btus to raise the water 1°F, or raising the temperature of 10 pounds of water 1°F requires (**10**) (**2**) times the Btus, so the formula is an easy one to work with.

e. In the (**Celsius**) (**metric**) system, the equivalent of a Btu is a kJ, kilojoule, and this is coupled with kg and °C to give the metric version of the Btu formula: 4.187 kJ of heat is required to raise the temperature of 1 kg of water 1 degree Celsius.

f. Btuh is British thermal units per hour, a way of measuring both heat gain and heat loss when referencing heating and cooling (**loads**) (**systems**) in heating, ventilating, air conditioning, and refrigeration design.

g. Btu, kJ, and Btuh are not used often in ACR service, but ACR technicians run into these terms often in ACR literature of all kinds and they need to know what they mean because they are significant concepts that are reflected in system (**design**) (**performance**).

***Permission to duplicate this test is granted.**

Special Tools and Measuring
Unit 4

Teacher Supplement 1—Make Conversions Using a Decimal Equivalent Chart

Directions: Convert fractions as decimal equivalents by reading from left to right on a decimal equivalent chart, and then read the chart left to right to convert decimal equivalents to fractions.

a. 1/16 = ____________________

b. 7/8 = ____________________

c. 1/4 = ____________________

d. 1/2 = ____________________

e. 9/16 = ____________________

f. 0.4375 = ____________________

g. 0.3125 = ____________________

h. 0.375 = ____________________

i. 0.125 = ____________________

j. .6875 = ____________________

1/64				.015625	33/64				.515625
	1/32			.03125		17/32			.53125
3/64				.046875	35/64				.546875
		1/16		.0625			9/16		.5625
5/64				.078125	37/64				.578125
	3/32			.09375		19/32			.59375
7/64				.109375	39/64				.609375
		1/8		.125			5/8		.625
9/64				.140625	41/64				.640625
	5/32			.15625		21/32			.65625
11/64				.171875	43/64				.671875
		3/16		.1875			11/16		.6875
13/64				.203125	45/64				.703125
	7/32			.21875		23/32			.71875
15/64				.234375	47/64				.734375
			1/4	.250				3/4	.750
17/64				.265625	49/64				.765625
	9/32			.28125		25/32			.78125
19/64				.296875	51/64				.796875
		5/16		.3125			13/16		.8125
21/64				.328125	53/64				.828125
	11/32			.34375		27/32			.84375
23/64				.359375	55/64				.859375
		3/8		.375			7/8		.875
25/64				.390625	57/64				.890625
	13/32			.40625		29/32			.90625
27/64				.421875	59/64				.921875
		7/16		.4375			15/16		.9375
29/64				.453125	61/64				.953125
	15/32			.46875		31/32			.96875
31/64				.484375	63/64				.984375
			1/2	.500				1	.000

Special Tools and Measuring
Unit 4

Teacher Supplement 2—Make Conversions Using an English-Metric Conversion Chart

Directions: Read the accompanying English-Metric Conversion Chart to make the following conversions from the English system of measurement to the metric system of measurement, and from metric to English. Be sure to follow directions included with the chart and be sure to multiply with the proper conversion factor.

a. 100 pounds of dog food = __________________ kilograms of dog food

b. 2.5 pounds of coffee = __________________ kilograms of coffee

c. 2 quarts of milk = __________________ liters of milk

d. 15 gallons of gasoline = __________________ liters of gasoline

e. 7 grams of disinfectant = __________________ ounces of disinfectant

f. 3 liters of coke = __________________ quarts of coke

g. If an automobile gets 40 kilometers per liter, how many miles per gallon will reflect the same performance ratio? __________________

Teacher Supplement 2

English-Metric Conversion Chart

	When You Know	You Can Convert To	When You Multiply By
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76
CAPACITY-VOLUME	Ounces	Milliliters (ml)	30
	Milliliters	Ounces	0.034
	Pints	Liters (l)	0.47
	Liters	Pints	2.1
	Quarts	Liters	0.95
	Liters	Quarts	1.06
	Gallons	Liters	3.8
	Liters	Gallons	0.26
	Cubic Inches	Liters	0.0164
	Liters	Cubic Inches	61.03
	Cubic Inches	Cubic Centimeters (cc)	16.39
	Cubic Centimeters	Cubic Inches	0.061
WEIGHT (MASS)	Ounces	Grams	28.4
	Grams	Ounces	0.035
	Pounds	Kilograms	0.45
	Kilograms	Pounds	2.2
FORCE	Ounce	Newtons (N)	0.278
	Newtons	Ounces	35.98
	Pound	Newtons	4.448
	Newtons	Pound	0.225
	Newtons	Kilograms (kg)	0.102
	Kilograms	Newtons	9.807

Teacher Supplement 2

English-Metric Conversion Chart

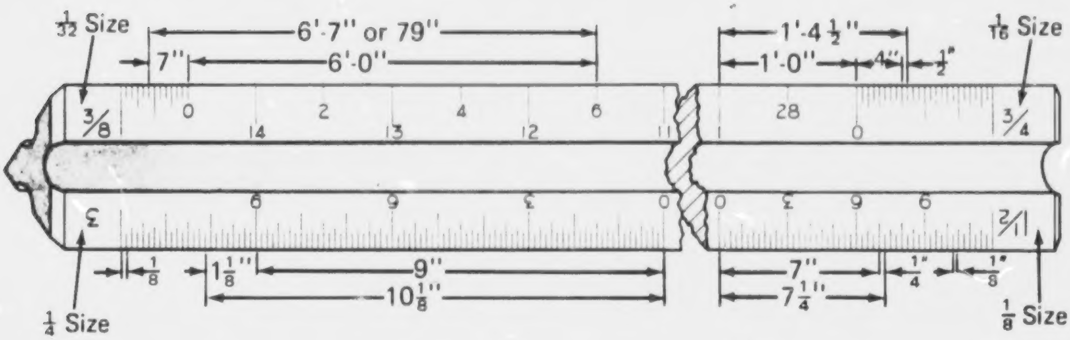
	When You Know	You Can Convert To	When You Multiply By
ACCELERATION	Inch/Sec^2	Meter/Sec^2	.0254
	Meter/Sec^2	Inch/Sec^2	39.37
	Foot/Sec^2	Meter/Sec^2 (m/s^2)	0.3048
	Meter/Sec^2	Foot/Sec^2	3.280
TORQUE	Pound-Inch (Inch-Pound)	Newton-Meters (N-M)	0.113
	Newton-Meters	Pound-Inch	8.857
	Pound-Foot (Foot-Pound)	Newton-Meters	1.356
	Newton-Meters	Pound-Foot	.737
PRESSURE	Pounds/sq. in. (PSI)	Kilopascals (kPa)	6.895
	Kilopascals	Pound/sq. in.	0.145
	Inches of Mercury (Hg)	Kilopascals	3.377
	Kilopascals	Inches of Mercury (Hg)	0.296
FUEL PERFORMANCE	Miles/gal	Kilometers/liters (km/l)	0.425
	Kilometers/liters	Miles/gal	2.352
VELOCITY	Miles/hour	Kilometers/hr (km/h)	1.609
	Kilometers/hour	Miles/hour	0.621
TEMPERATURE	Degrees Fahrenheit	Degrees Celsius	5/9(F°-32)
	Degrees Celsius	Degrees Fahrenheit	9/5(C°)+32=F°

Special Tools and Measuring
Unit 4

Teacher Supplement 3—The Architect's Scale

As the name implies, the architect's scale is designed for architects and their profession, but use of the scale is certainly not limited to architects. In fact, the scale is the ideal instrument for anyone who has to read a print on a job site. For ACR technicians, the ¼" architect's scale provides a measuring tool made to order for reading house and equipment prints that are frequently presented in a ¼" = 1' scale. The ¼" architect's scale can be put to good use in the job sheets in Unit 5, "Tubing and Tubing Applications", and again in Unit 9, "Silver Brazing" where students must complete a project assembly that requires critical measurement.

Reading the ¼" architect's scale is not difficult. The major marks are ¼" apart and each of these marks represent 1'. To the left of the 0 mark is a scale that represents inches on the ¼" scale. Since the marks are to scale, there are 12 marks to indicate 12". This feature provides an acceptable tolerance for reading working print specifications. Note in the following graphic that other architect's scales read just like the ¼" scale. With little effort a student can acquire a valuable measuring skill that will increase job performance.



Teacher Supplement 3

For a practical application, students should have an ¼" architect's scale available when they are cutting and bending tubing for the job sheets in Unit 5. Since the tubing from the Unit 5 job sheets will be used for the Project Assembly in Unit 9, "Silver Brazing", students will learn more by applying the scale to parts that will be used in the assembly. Note in the following photo that the ¼" inch architect's scale is demonstrated on a ¼" = 1' working print.

Special Tools and Measuring
Unit 4

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Measure Lines to the Nearest Quarter, Eighth, and Sixteenth of an Inch Rating ______

Comments: ______________________

Assignment Sheet 2—Read a Rule Rating ______

Comments: ______________________

Assignment Sheet 3—Measure Selected Items With Slide Calipers Rating ______

Comments: ______________________

Job Sheet 1—Grind the Head of a Chisel or Punch Rating ______

Comments: ______________________

Job Sheet 2—Sharpen a Chisel or Screwdriver Rating ______

Comments: ______________________

Other ______________________

Unit Evaluation Form

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

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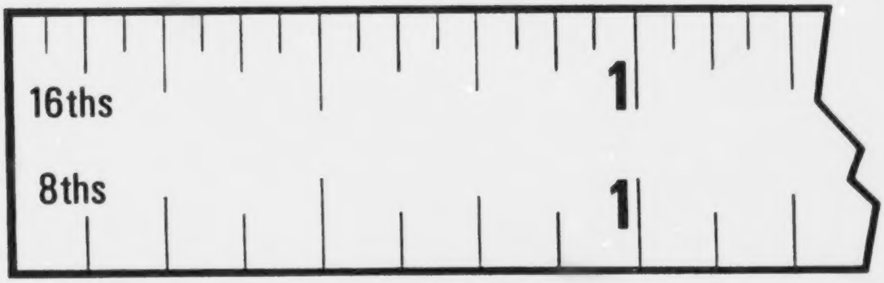
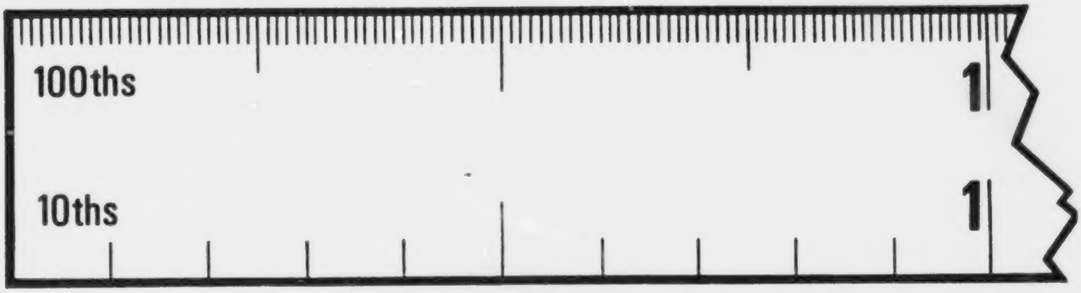
*Permission to duplicate this form is granted.

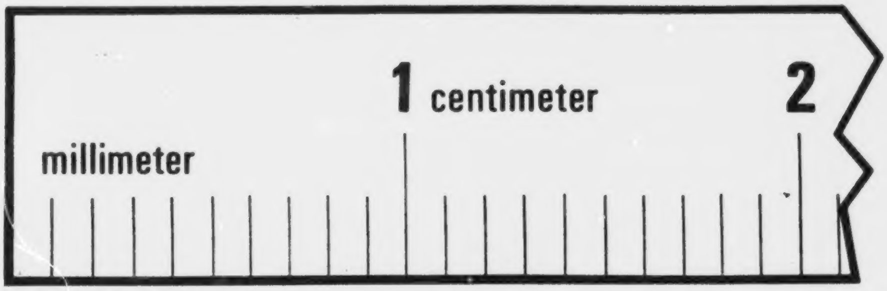
Units of Measurement


16ths
8ths
1
1

Fractional Rule


100ths
10ths
1
1

Decimal Rule


1 centimeter
2
millimeter

Metric Rule

Special Tools and Measuring
Unit 4

Information Sheet

1. **Terms and definitions**

   a. **English system** — A system of measurements based on units that vary by application such as pounds and ounces for weight and inches and feet for length

   b. **Hygrometer** — An instrument that senses and measures humidity

   c. **Interpolating** — Estimating unknown values by referencing known values

   d. **Manometer** — A U-shaped tube filled with mercury or water with a graduated scale for reading the pressure of gases

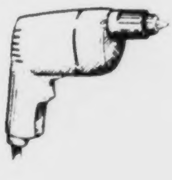
   e. **Metric system** — A system of measurements based on units of ten; also known as the International System of Units because of its adoption by the international scientific community

   f. **psia**— Pounds per square inch absolute, a pressure reading where zero does not include the 14.7 pounds per square inch exerted by atmospheric pressure

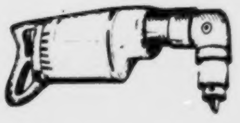
   g. **psig** — Pounds per square inch gauge, a pressure reading where zero does include the 14.7 pounds per square inch exerted by atmospheric pressure, and often abbreviated to psi

2. **Guidelines for working with drills and power screwdrivers**

   a. Electric-powered hand drills are configured for drilling straight into wood or metal, and some are configured with a 90° offset so they can be used in areas with limited work space.

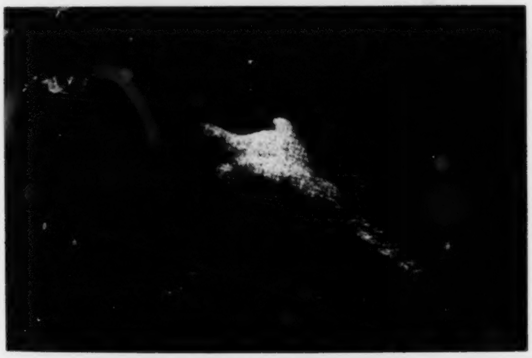


Straight drill



Offset drill

b. Battery-powered drills and screwdrivers can also be used for drilling, and their light weight, portability, and versatility make them popular tools at the jobsite.

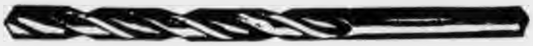


c. Several battery-powered drills and screwdrivers have adjustable torque so they can be used with a drill bit, or with power bits for several types of screwdrivers, and bits for nut drivers that are essential for working with sheet metal screws.

d. Many battery-powered screwdrivers have extra battery packs so a charged pack can be quickly installed and work can continue while a dead battery is being recharged.

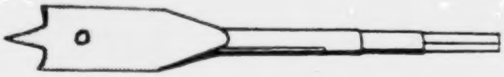
e. Keep an assortment of drill bits for metal, wood, and masonry.

Twist drill bit for metal

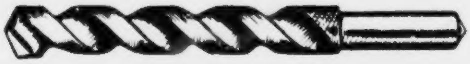


Information Sheet

Wood drill bit for wood



Masonry drill bit for concrete



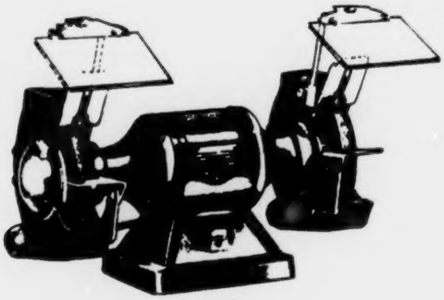
f. Some drills and screwdrivers have a keyless chuck because it eliminates the need for a chuck key which is very easy to lose; older drills can be modified for a keyless chuck.

g. If a drill has a chuck key, attach it to the drill; chuck keys vanish into thin air for no reason at all, and hunting an elusive chuck key wastes time on the job.

Information Sheet

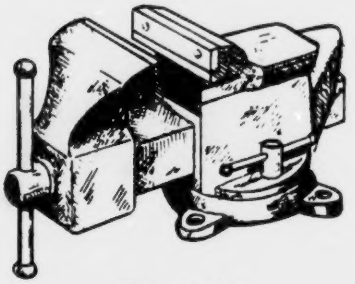
3. Use and care of grinders, vises, and presses

a. Keep the tool rest on a bench grinder tight, and keep the safety shield clean and in place.

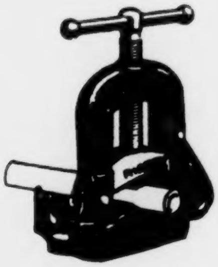


b. Dress the grinding wheel on a bench grinder when a grinding job takes too long or the wheel becomes laden with fragments from previous jobs.

c. Keep bench vises and pipe vises clean, and lightly oil the clamping screw if it appears to be dry.



Bench vise



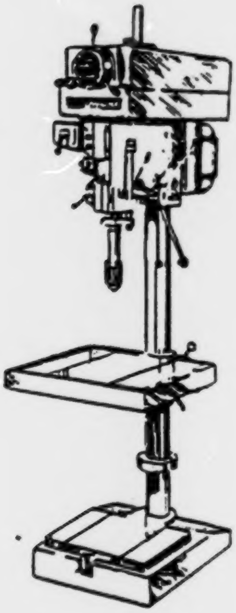
Pipe vise

d. Do not hammer on the jaws of any vise, and do not overtighten a vise or hammer on the tightening handle except to loosen the handle with a light tap of a soft-face mallet.

e. Use bench vises for holding objects in place, but use pipe vises only for securing pipe or conduit, and remember that conduit is easy to accidentally bend in a vise.

Information Sheet

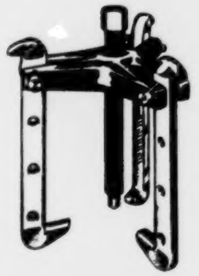
f. Keep drill presses clean, keep guards in place, and use the press only for drilling; do not hammer or cut on a drill press.



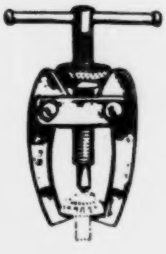
g. Sweep up metal shavings that collect on or around a drill press because the sharp edges of shavings pose a safety hazard both in the shop and on a worksite.

4. **Use and care of pullers**

a. A wheel puller is used for removing pulleys and bearings from motor shafts, and a gear puller is used for removing pulleys and gears from motor shafts.



Wheel puller



Gear Puller

Information Sheet

b. Oil the threaded shaft on pullers at needed intervals, keep the tips pointed so they will hold tightly, and do not drop a puller because they have sensitive balance.

c. A fan blade puller is used to remove the fan from a shaft, and the shaft will usually require light oiling to facilitate removing the blade.

Fan blade puller

5. Caring for drilling tools

a. Keep motor-cooling openings on all power equipment clean and open.

b. Check for cord breaks on electric-powered drills, never pick up a drill by the cord, and never try to unplug a drill by jerking on the cord; grasp the cord at the plug.

c. Do not overload a drill, and do not drop a drill.

d. Keep drill bits stored in a box, and never force a drill bit.

e. Use twist drills tor metal, wood drills for wood, and never use a wood or masonry drill for metal.

f. Apply cutting oil when drilling thicker metals, and use water for cooling a masonry bit cutting concrete or stone.

g. Keep power bits for power screwdrivers in order in a closed case; if they are thrown into an open tool box, they become difficult to find.

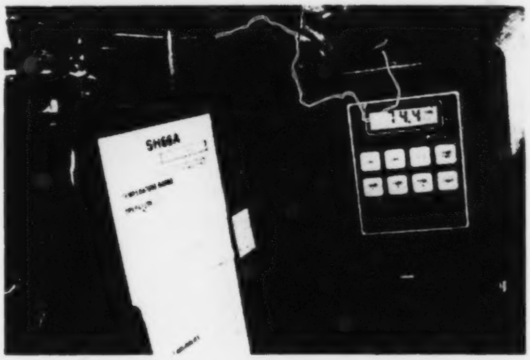
Information Sheet

6. Use and care of thermometers

a. Portable pocket thermometers clip into a shirt pocket and are handy for temperature measurement at almost any point in a system.

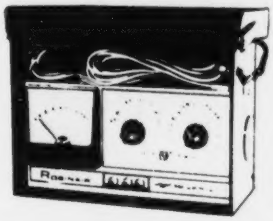
b. Pocket thermometers are also available in Fahrenheit and Celsius scales, and some models have both scales on one instrument.

c. Remote bulb thermometers are especially designed to provide a readout for temperature sensed in a remote area that a technician cannot physically access.



d. Pocket and remote bulb thermometers are available in several temperature ranges, but the –40° to +120° range is the type most often used.

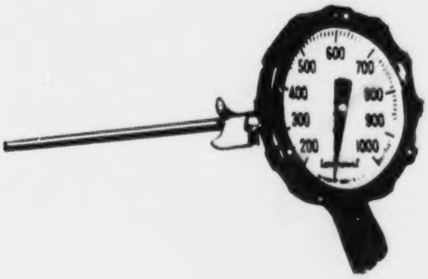
e. The thermal electric thermometer is designed for measuring a broad range of temperatures, from –50° to +1000°, and some types have multiple leads that permit the measurement of more than one temperature.



Information Sheet

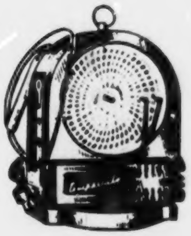
f. The digital thermometer is the easiest of all thermometers to read, and is preferred where an extremely accurate temperature reading is required, and they are available in several configurations ranging from pocket types to models with remote sensing devices.

g. Flue and stack thermometers are designed for measuring temperatures in furnace flues and stacks, and their range is usually from 200°F to as much as 1000°F.

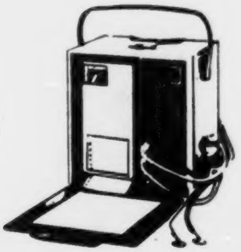


h. Recording thermometers keep track of temperature over periods of hours, days, or even weeks.

i. Wind-up manual recording thermometers often record on a circular chart, electric models usually record on a strip chart, and computer-controlled models print out a temperature chart at programmed intervals.



Manual wind-up recording thermometer



Electric recording thermometer

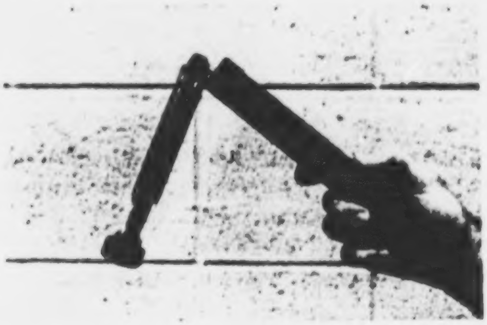
j. Never drop a thermometer, keep them clean, check batteries often, if they are battery-operated, and use thermometers for their intended temperature ranges.

Information Sheet

7. Use and care of hygrometers

a. Hygrometers are a general class of instruments that help ACR technicians measure relative humidity outside, in a room, or in any air-conditioned space.

b. The sling psychrometer is a portable hygrometer with a wick that a technician wets with distilled water; the water evaporates when the psychrometer is whirled around and provides a "wet bulb" or humidity reading.

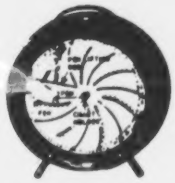


c. A dial-type hygrometer is built with a highly sensitive human hair that responds to humidity changes and provides a readout.

0
10
20
30
40
50
60
70
80
90
100
relative humidity

Information Sheet

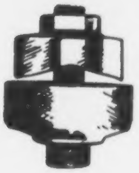
d. A humidity recorder keeps track of humidity changes over a period of time by tracking the changes on a circular chart.



e. Keep all hygrometers clean, keep sling psychrometers in a box when not in use, use a fresh wick each time a humidity test is made, and never drop one of these carefully calibrated instruments.

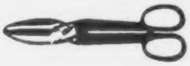
8. Use and care of sheet metal tools in ACR work

a. Use a knockout cutter for making holes in sheet metal, especially for holes in cabinets that will be used for electrical conduit and refrigerant lines.



b. Do use a knockout cutter on thick sheet metal; it will dull the cutter and maybe damage the sheet metal.

c. Use combination pattern snips for general sheet metal cutting; they are designed to make metal curl up out of the way when making circular cuts.

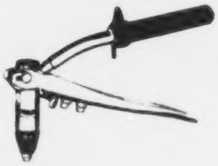


Information Sheet

d. Use a hand notcher for cutting uniform edges in sheet metal.

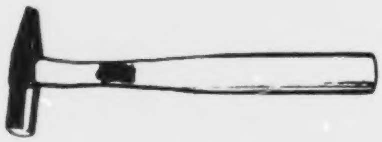
e. Use a hand seamer when forming a seam on a piece of sheet metal.

f. Use a riveter for joining pieces of sheet metal together.

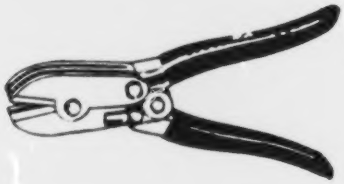


Information Sheet

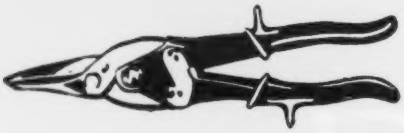
g. Use a riveting hammer to form sheet metal; the hammer edges are beveled to prevent marking the sheet metal.



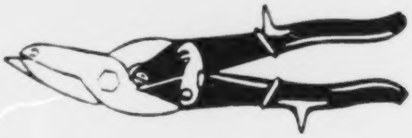
h. Use a hand crimper fro shaping the end of flue or other pipe that has to be fitted together.



i. Use aviation snips for cutting sheet metal in a right-handed or left-handed direction.



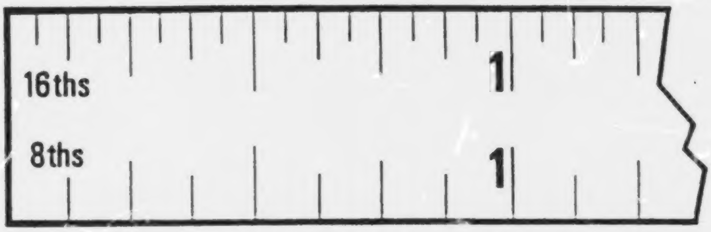
j. Use double-cutting snips for cutting when both pieces of sheet metal must lie flat.



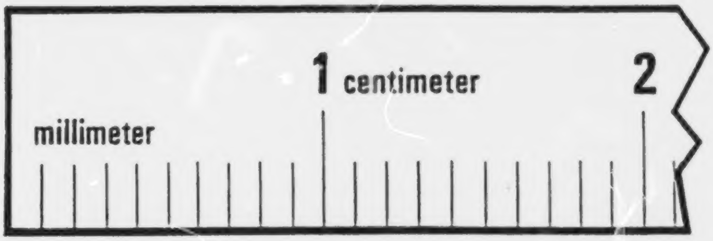
Information Sheet

9. Guidelines for measuring distances

a. Standard measuring means using a fractional rule to measure in yards, feet, inches, or fractions of an inch.

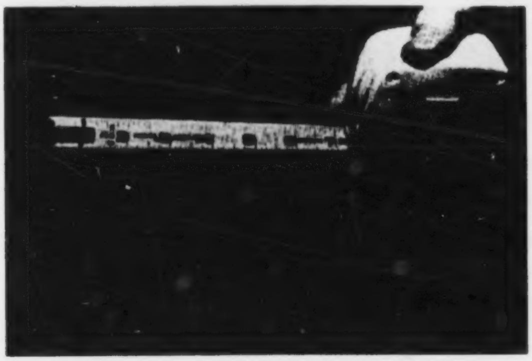


b. Metric measuring means using a metric rule to measure in meters, decimeters, centimeters, or millimeters.



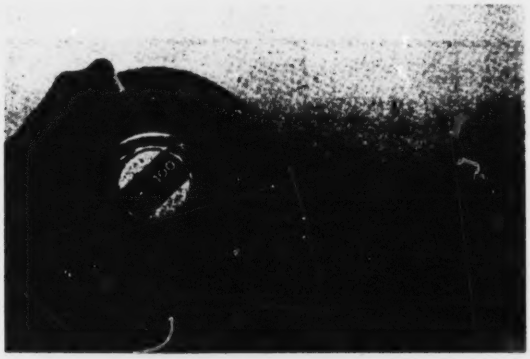
c. Measuring in ACR work often means measuring straight distances, but can require measuring through the center of a circular object to determine diameter, or around a circular object, such as ductwork, to determine circumference.

d. ACR technicians mostly use retractable tapes because they're highly portable, handy because they snap right over a technician's belt and versatile because most can measure up to several feet in increments down to $\frac{1}{16}$ of an inch.



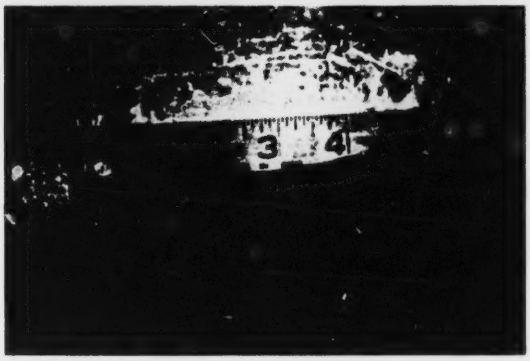
Information Sheet

e. Carpenter's roll-up tapes are used for measuring long distances, and folding carpenter's rules are also common around a jobsite because they are rigid and can be used for measuring upward where a retractable tape would bend.



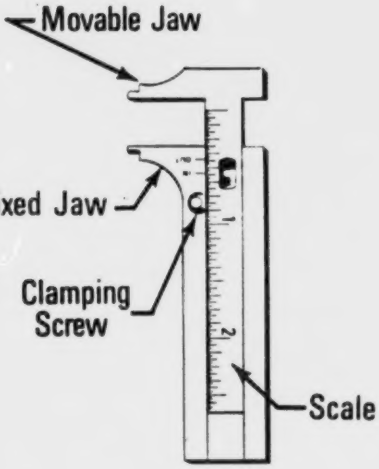
f. Combination squares are handy for measuring short distances and for checking the square of cabinets and wooden framing.

g. Tempered steel rules, especially circumference rules, are used for sheet metal layout because a scratch awl slides easily along the tempered edge.



Information Sheet

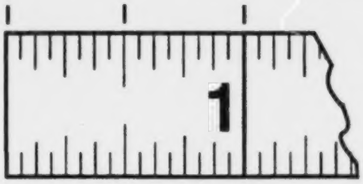
h. Slide calipers are used for critical measurements that need to be within 1/32″; calipers can measure both inside and outside diameters, and are used to measure the outside diameter of fan shafts and the inside and outside diameters of pipe.



10. How to read rules and tape measures

a. Inches and feet are the major divisions of a rule or tape measure, but the distances less than an inch start by dividing an inch into two equal parts so that two ½″ segments equal and inch.

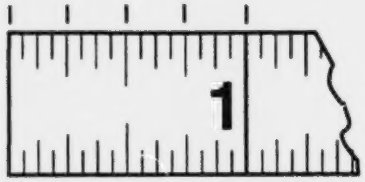
Example:



Information Sheet

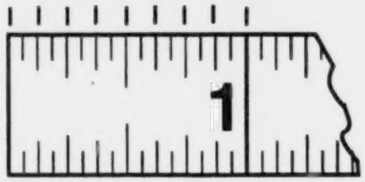
b. For more exact measurement, an inch is divided into four equal parts so that four 1/4″ segments equal an inch.

Example:



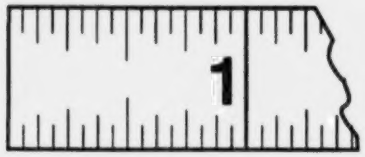
c. For more exact measurement than 1/4″ segments, an inch is divided into eight equal parts so that eight 1/8″ segments equal an inch.

Example:



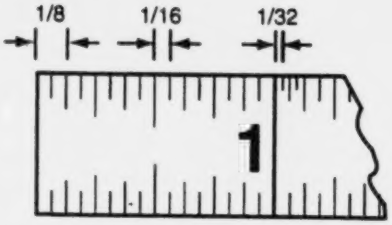
d. For more exact measurement that 1/8″ segments, an inch is divided into sixteen equal parts so that sixteen 1/16″ segments equal an inch.

Example:



e. For more exact measurement than 1/16″ segments, an inch is divided into thirty-two equal parts so that thirty two 1/32″ segments equal an inch; the 1/32″ increments do appear on some rules and tapes, but for critical measurements, calipers are usually used.

Example:



f. In ACR service, it is a trade practice to use the ′ sign to indicate the number of feet in a measurement, and the ″ sign to indicate the number of inches.

Information Sheet

g. In writing a measurement, the number of feet are presented first and indicated with the foot (′) sign, the number of inches are presented second followed by the inch (″) sign, or if there are fractions of an inch, the inch sign (″) follows the fraction.

Example: 7′6″; 7′6¾″

h. In calling out a measurement, simply speak the terms in order:

Example: Seven feet, six and three-quarters inches.

11. Metrics in the American workplace

a. Most of the countries not on the metric system started converting to the metric system in the early 1970s, but although metrics are the streamlined, easy way to measure anything, America has never officially "gone metric."

b. But official or not, the metric system is working in America and it is here to stay because more than ever before, American industries are competing in a global market, and that market measures in metrics.

Note: As of this writing, Burma, Liberia, and the United States are the only countries that have not made the official conversion to metrics.

c. Being aware of metrics is almost as important as using metrics, and this is especially true in the ACR industry where the rush to manufacture replacement refrigerants for R-11, R-12, and R-502 have inspired an influx of refrigerants that are measured in kg (kilograms) instead of lbs. (pounds) and where pressures are measured in kPa (kilopascals) instead of psi (pounds per square inch).

d. American industries that have had to keep overseas metric inventory and American inventory based on the English system of measurement are losing a great deal of money by working with two systems, and changes are underway in all industries to solve the problem by "going metric."

e. For ACR technicians, the metric experience should be an easy one because many labels include both metric and English measures; another reason the conversion should be easy is that conversion factors help make the switch from English to metric an easy one.

Note: Measurements in pressure, temperature, and weight are given in the objectives that follow to familiarize yourself with metric names that you will confront in ACR literature and at other points in the workplace.

12. Interpolating with math and measurement

a. Interpolating is a process of finding unknown quantities by making intelligent references from known values.

Example: If gas is $1 a gallon and we know some basic multiplication, we know that 5 gals of gas will cost $5—that's math, but if we have only $2.33 in our pocket, we know we can get more than two gallons of gas, but less than three. We may call this process intelligent guessing, but the minute we realize that we can buy 2 gallons of gas and that the 33 cents will buy about $\frac{1}{3}$ of a gallon more, then we're interpolating.

b. Interpolating is a time saver, and people who practice it become good at it; it is an especially effective way to work with quantities in a series when some of the quantities aren't given; most charts are like that because in between quantities can be easily estimated from the known quantities that are given.

Example: In the series 2, 4, 6, 8, 12, 14, we look at it and immediately know the missing quantity is 10; in other words, we know that the series jumps in twos and that the jump from 8 to 12 is 4, so we interpolate and come up with 10.

c. Interpolation might give an answer high or low if you're looking for precision, but at other times interpolation can provide time saving answers, especially at a job site where getting out a paper and pencil to "figure with" can completely stop an installation or service activity.

13. Decimal equivalents and their applications

a. Adding, subtracting, and multiplying fractions is a time-consuming chore that requires several steps and employs some rules that are often forgotten because so few people actually work with fractions on the job.

Example: To find the answer to something as simple as multiplying $\frac{1}{2} \times \frac{3}{4}$, we first have to find a common denominator for the two fractions, in this case it is 4, so we have $\frac{2}{4} \times \frac{3}{4}$, which gives us $\frac{6}{8}$ which we then reduce to lowest terms to get $\frac{3}{8}$. Try the process with $\frac{52}{64} \times \frac{13}{32}$, and you will be awhile, and maybe even make some mistakes along the way.

Information Sheet

b. A decimal equivalent chart converts fractions into decimals so they can be added, multiplied, subtracted, or divided with greater speed and less chance for error.

Example: The decimal equivalent for ½ is .500 (pretty easy to remember) and the decimal equivalent for ¾ is .750 (still pretty easy to remember). Multiply .750 × .500 and the result is .375. When we convert that to a fraction using the decimal equivalent chart, it comes out ⅜. In other words, we get the same answer as in the previous example, but we got there with just one step. With other fractions, the process of finding common denominators, adding, and subtracting, can really become time consuming even to people pretty good at math.

c. A decimal equivalent chart is a handy tool for technicians who work with rules or tapes that have fractions used to measure everything from bolt sizes to the length of refrigerant lines.

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.250	3/4	.750
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.500	1	.000

Information Sheet

14. Measuring and converting pressure readings

a. ACR gauges measure pressure in psig, pounds per square inch gauge, usually shortened to psi to indicate that the gauge is compensating for 14.7 pounds of atmospheric pressure.

b. In some ACR service literature it is fairly common to run into references to psia; this means a pressure reading with the absence of atmospheric pressure as a reference point and is called psia, pounds per inch absolute.

c. Readings for psia pressures sometimes appear in ACR service literature, so when you confront a psia reading and need to convert it to psig, add 14.7.

Example: 20 psi = 34.7 psig because 20 + 14.7 = 34.7.

d. As America becomes more and more a part of a global marketplace, more and more pressure readings are stated in kilopascals, the metric reference for pressure.

e. The kilopascal is noted as kPa, and 1 kPa = .143 psi while 1 psi = 7.0 kPa.

f. Converting from psi to kPa or from kPa to psi can be accomplished with some educated guessing if you reference known pressures and then interpolate.

Example: In the following conversion table we know that 50 psi equals 350 kPa, so if we multiply each reading by 10 we know that 500 psi equals 3500 kPa. Since we can see that 100 psi = 700 kPa and that 200 psi = 1400 kPa, we can safely interpolate that 150 psi would equal 700 kPa + 350 kPa or 150 psi = 1050 kPa. With basic reference points, interpolation is a useful mathematical tool that can be put to work on the job.

Basic psi, kPa Conversions

kPa	0	350	700	1400	2800	3500
psi	0	50	100	200	400	500

15. Measuring and converting vacuum readings

a. Measuring a vacuum means measuring any pressure less than atmospheric pressure; zero on the psia scale indicates a perfect vacuum or the deepest vacuum that can be measured.

b. A vacuum is measured by removing pressure from liquids enclosed in a column, and several liquids, including water, are used, but Mercury has proved to be the best liquid for the application, and vacuums are almost always measured in inches of Mercury, noted as in Hg.

Information Sheet

c. Beyond certain levels, vacuums are measured in microns because the measurements, at certain levels, are more accurate than can be obtained with gauge readings.

d. The compound gauge on a technician's manifold gauge set is designed especially to measure vacuums in inches of Mercury, but some literature expresses vacuums metrically, and this means they have to be measured in centimeters of Mercury, usually using a mercury manometer.

e. Centimeter is noted as cm, and 1 cm = 0.4 in. while 1 in. = 2.54 cm.

f. Converting from cm to in. or in. to cm is best accomplished by using the 0.4 in. or 2.54 cm conversion factors.

Example: 20 in. Hg × 2.54 = 50.8 cm Hg. The following chart lists some common vacuum readings and shows the cm/in conversions along with the micron readings which are useful when precise evacuation measurements are required.

Basic In. Hg/cm Hg/micron Conversions

cm	0	45.7	73.48	75.75	75.90	76.00
in.	0	18.0	28.93	29.82	29.88	29.92
microns	760,000	300,000	25,000	2,500	1,000	0

16. Measuring and converting temperature readings

a. Temperature readings in ACR service are mostly taken in degrees Fahrenheit (°F), but Celsius readings are often referenced, and technicians need to be able to convert from °F to °C.

Note: Celsius and centigrade are the same scales with the freezing point of water at 0°C and the boiling point of water at 100°C; Celsius is named after the Swedish astronomer Anders Celsius who originated the scale.

b. Because technicians may confront service literature with references in °C, converting C into F will probably be a more common need than converting F into C, so, the formula for converting C to F is $\frac{9}{5}$°C + 32 = °F.

c. The formula in item b provides a good example of how a decimal equivalent can be put to good use because finding $\frac{9}{5}$ of a Celsius reading requires dividing a fraction when the same answer can be obtained by multiplying the decimal equivalent of a fraction.

Example: If we have 20°C to convert to °F, we have to divide 20 by 5 to get 4, and then multiply 4 by 9 to get 36. Now we add 36 to 32 and 20°C = 68°F. By using the decimal equivalent of $\frac{9}{5}$, we get 1.8 × 20 = 36.0 + 32 = 68°F. Using the decimal equivalent saves a couple of steps and with many fractions, the decimal equivalent is much easier to work with.

d. In cases where °F have to be converted to °C, the formula is $\frac{5}{9}$ × the degrees in F minus 32, expressed as $\frac{5}{9}$ (°F – 32).

Example: $\frac{5}{9}$ of 68°F – 32 or $\frac{5}{9}$ of 36 = 4 × 5 = 20°C.

17. Measuring and converting weight readings

a. Refrigerants and refrigerant cylinders have to be carefully weighted because refrigerant is sold by the pound, but also because refillable cylinders are sometimes refilled by weight.

b. To help service technicians with their bookkeeping, refrigerant cylinders are stamped with what is called a tare weight, the weight of the cylinder when it is empty; this way, the difference between the tare weight and the gross weight is net weight of refrigerant added to an empty cylinder.

c. Another important safety aspect of refilling a refrigerant cylinder is that it should never be filled to more than 80% by weight of its maximum water capacity, meaning that a cylinder with a 26.2 lb. water capacity should not be filled with more than 20.9 lbs. of refrigerant.

Example: Allowable gross weight = (water capacity weight × 0.8) + tare weight.

d. The rule about 80% is so important that some cylinders have automatic fill switches that cut recovery equipment off when a tank reaches 80% of its capacity, but when a fill switch is not installed, the refrigerant cylinder has to be weighted.

Information Sheet

e. In a typical situation, with ambient temperature below 130°F, it is probably wise to stay just a bit below the 80% mark, but a technician must know what the figure is before starting the refill activity.

Example: After refilling, a cylinder with a 26.2 lb. water capacity with a tare weight of 13.7 lbs., the gross weight is 33.7 lbs. How much refrigerant is in the cylinder? We subtract the tare weight, 13.7 lbs. from the gross weight of 33.7 lbs. and that equals 20 lbs. of refrigerant. If the ambient temperature is no more than 130°F, it is safe to put 20.9 lbs. of refrigerant in the cylinder, so with the 20 lb. figure, there is a margin of safety in the refilling activity.

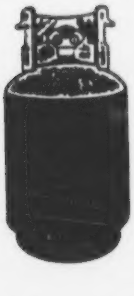
f. To handle refrigerants and cylinders marked in kilograms and grams requires some simple conversions: 1 lb. = 45 kg and 1 kg = 2.2 lbs. and 1 oz. = 28.4 g and 1 g = .035 oz.

Basic lb./kg Conversions

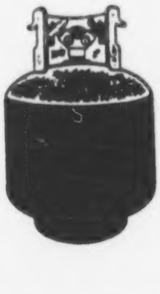
kg	1	10	20	30	40	50	100
lb	2.2	22	44	66	88	110	220

Note: Here again, interpolation can be used to make quick conversions; if a cylinder has a 26.2 lb. water capacity, we know this would be 10 kg plus a little 1 kg (2.2 lbs.), but that would make only 22 + 2.2, or 24.2 lbs., so we need another 1 kg (2.2 lbs.), but that would make it 26.4 lbs. which is too much, so we have to back off about .5 kg and come up with 11.5 kg. The actual figure, would be 11.7 kg, but the 11.5 is close enough to keep within safety guidelines.

g. A handy reference to lb./kg conversions is to keep in mind the typical water capacity of standard cylinder sizes and their relationships and lbs. and kgs.



23.2 lb. = 11.7 kg



47.7 lb. = 21.4 kg

240 lb. = 108 kg

Courtesy Worthington Cylinder Corporation

Information Sheet

18. Measuring Btu and Btuh

a. A Btu is a British thermal unit, the industry standard for measuring heat gain and heat loss; when expressing heat gain, a Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

b. When expressing heat loss, a Btu is the amount of heat that must be removed from 1 pound of water to lower the water 1 degree Fahrenheit.

c. The Btu formula is based on the specific heat of water; to apply the formula to other liquids or substances requires the specific heat of the substance.

d. In application, raising the temperature of water 10°F would 10 times the Btus to raise the water 1°F, or raising the temperature of 10 pounds of water 1°F requires 10 times the Btus, so the formula is an easy one to work with.

Example: To raise 10 lbs. of water from 70°F to 75° would require 5 Btu + 10 Btu for a total of 15 Btu; the temperature differential can be figured from any given point to any projected point.

e. In the metric system, the equivalent of a Btu is a kJ, kilojoule, and this is coupled with kg and °C to give the metric version of the Btu formula: 4.187 kJ of heat is required to raise the temperature of 1 kg of water 1 degree Celsius.

f. Btuh is British thermal units per hour, a way of measuring both heat gain and heat loss when referencing heating and cooling loads in heating, ventilating, air conditioning, and refrigeration design.

g. Btu, kJ, and Btuh are not used often in ACR service, but ACR technicians run into these terms often in ACR literature of all kinds and they need to know what they mean because they are significant concepts that are reflected in system performance.

Special Tools and Measuring
Unit 4

Assignment Sheet 1—Measure Lines to the Nearest Quarter, Eighth, and Sixteenth of an Inch

Name ______________________ Overall Rating ____________

Evaluation Criteria	**Rating**
Number of quarter inch measurements properly made	____
Number of eighth inch measurements properly made	____
Number of sixteenth inch measurements properly made	____

1. Measure these lines to the nearest quarter of an inch.

   a. ________________________________

   b. ____

   c. __________

   d. ____________________

   Answers

   a. ____

   b. ____

   c. ____

   d. ____

Assignment Sheet 1

2. Measure these lines to the nearest eighth of an inch.

a. ____

b. ________________________

c. ___________________________________

d. ____

Answers

a. _____

b. _____

c. _____

d. _____

3. Measure these lines to the nearest sixteenth of an inch.

a. _______________________________________

b. __________

c. _________________________

d. ________________________________

Answers

a. _____

b. _____

c. _____

d. _____

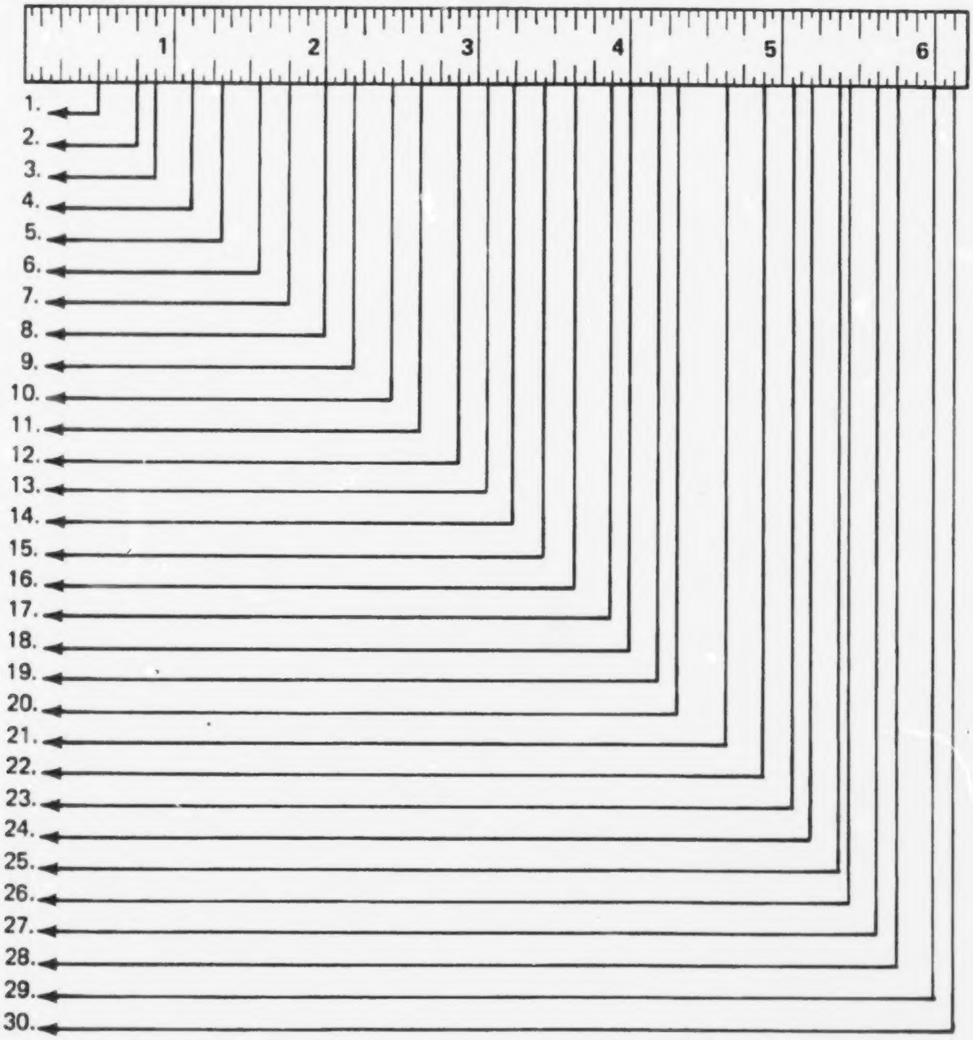
Special Tools and Measuring
Unit 4

Assignment Sheet 2—Read a Rule

Name ______________________ Overall Rating ____________

Evaluation Criterion	**Rating**
Number of correct readings	______

Directions: Include total measurement, and put answer on the arrow line.


1
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28.
29.
30.

Special Tools and Measuring
Unit 4

Assignment Sheet 3—Measure Selected Items with Slide Calipers

Name ______________________________ Overall Rating ____________

Evaluation Criteria	**Rating**
Number of correct O.D. readings	_____
Number of correct I.D. readings	_____
Number of other correct readings	_____

Directions: Your instructor will provide materials or direct you to materials to use for this activity. Measure the outside or inside diameter or other dimensions as directed, and note measurements to the nearest $\frac{1}{32}''$ when appropriate. However, just because you are working with a measuring tool that will measure $\frac{1}{32}''$, do not use the $\frac{1}{32}''$ increment unless it is appropriate to the measurement.

a. The outside diameter of a shaft: ______________________________

b. The outside diameter of a bolt: ______________________________

c. The inside diameter of a pipe: ______________________________

d. The inside diameter of a bearing: ______________________________

Special Tools and Measuring
Unit 4

Job Sheet 1—Grind the Head of a Chisel or Punch

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	Rating
Safe use of grinding equipment	______
Edges straight and smooth	______
No discoloring from overheating	______

A. Tools and materials

Chisel and/or punch
Bench grinder
Water tray
Safety glasses or goggles and a clear face shield

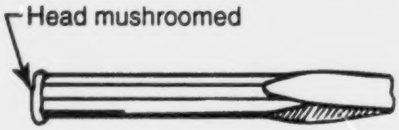
B. Procedure

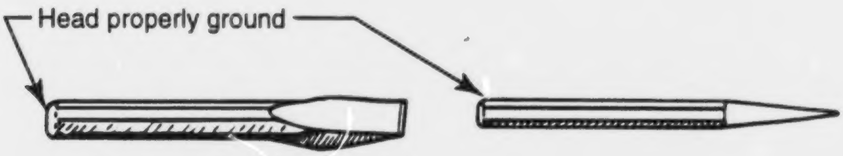
☐ 1. Put on safety glasses or goggles and a face shield.

☐ 2. Adjust clearance of the tool rest to about ⅛" from the grinding wheel.

Note: Be sure to dip the head of the chisel or punch into the water tray every now and then as you grind; this helps maintain the temper of the steel because too much heat will destroy temper.

☐ 3. Turn on grinder and grind a bevel on the head, and beware of flying chips.





Job Sheet 1

☐ 4. Make sure the head is clean and level.

☐ 5. Have your instructor check your work; clean up area and put tools away.

Evaluator's comments: ______________________________

____

____

Special Tools and Measuring
Unit 4

Job Sheet 2—Sharpen a Chisel or Screwdriver

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Safe use of grinding equipment	______
Edges straight and smooth	______
No discoloring from overheating	______

A. Tools and materials

Chisel and/or punch
Bench grinder
Water tray
Safety glasses or goggles and a clear face shield

B. Procedure

☐ 1. Put on safety glasses or goggles and a face shield.

☐ 2. Adjust clearance of the tool rest to about ⅛" from the grinding wheel.

☐ 3. Turn on grinder.

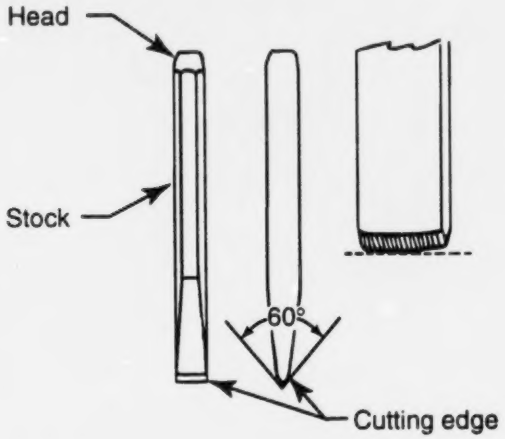
☐ 4. Hold the chisel's cutting edge against the grinding wheel while exerting a little pressure.

☐ 5. Grind the edge straight and smooth.

☐ 6. Dip the edge of the chisel in the water tray every now and then to cool it.

Job Sheet 2

☐ 7. Grind the edge on a slight curve, and be sure to keep a firm grip and apply pressure lightly as you grind.


Head
Stock
60°
Cutting edge

☐ 8. Have your instructor check your work; clean area and put tools away.

Evaluator's comments: ____________________

____

____

Tubing and Tubing Applications
Unit 5

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify selected fittings for copper tubing, make a single flare with a compression-type flaring block, make a single flare with a Rol-Air®-type flaring block, make a swage joint, make 90° and 180° tubing bends, and make a 45° offset in copper tubing. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to tubing and tubing applications with their correct definitions.
2. Match kinds of tubing with their applications.
3. Complete statements about the advantages of copper tubing in ACR applications.
4. Complete statements about characteristics of type K copper tubing and its applications.
5. Complete statements about characteristics of type L copper tubing and its applications.
6. Complete statements about characteristics of type M copper tubing and its applications.
7. Complete statements about characteristics of DWV tubing and its applications.
8. Match tubing fittings with their characteristics.
9. Identify flare fittings.
10. Identify flare-to-pipe fittings.

Objective Sheet

11. Identify compression fittings.

12. Identify sweat fittings.

13. Match quick connect fittings with their applications.

14. Select true statements about guidelines for cutting and reaming tubing.

15. Complete statements about guidelines for flaring tubing.

16. Select true statements about guidelines for swaging tubing.

17. Select true statements about tools for bending tubing.

18. Identify selected fittings for copper tubing. (Assignment Sheet 1)

19. Make a single flare with a compression-type flaring block. (Job Sheet 1)

20. Make a single flare with a Rol-Air®-type flaring block. (Job Sheet 2)

21. Make a swage joint in copper tubing. (Job Sheet 3)

22. Make a 90° bend in copper tubing. (Job Sheet 4)

23. Make a 180° bend in copper tubing. (Job Sheet 5)

24. Make a 45° offset bend in copper tubing. (Job Sheet 6)

Tubing and Tubing Applications
Unit 5

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with objectives as indicated.

   TM 1—Flare Fittings (Objective 9)
   TM 2—Flare-to-Pipe and Compression Fittings (Objectives 10 and 11)
   TM 3—Sweat Fittings (Objective 12)
   TM 4—Quick-Connect Fittings (Objective 13)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the assignment sheet and the evaluation criteria; prepare items as indicated for Assignment Sheet 1 so that students will have to demonstrate the ability to really differentiate types of fittings by general class and specific application.

11. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test items as needed.

14. Give written test.

15. Compile assignment sheet rating, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Impress upon students the importance of using proper type of tubing for a given application. Have samples of all types of tubing to present to the class as they study the early objectives in the unit. Skill areas: **Learning skills, learning to learn.**

2. Read Assignment Sheet 1 carefully and prepare and tag items for students to identify. Stress the need for being able to differentiate general types of fittings from each other and the importance of selecting the specific fitting for a given application. Skill areas: **Foundation skills, science.**

3. Order the video materials presented at the end of Suggested Activities. This is a professional production which would impress students with the finer points of cutting tubing, flaring tubing, and swaging tubing. Show the video and have students discuss it together. Skill areas: **Foundation skills, science and math.**

4. Read Job Sheets 4, 5, and 6 carefully because tubing that students bend in these job sheets should be saved for the brazing project in Unit 9. In fact, you might have students look at the brazing project form Unit 9 before they start bending tubing. Let them perform the proper measuring as part of the job sheets. Not only will it help conserve materials, it will give the students a chance to do some project planning on their own. Skill areas: **Foundation skills, math.**

Suggested Activities

Resources Used in Developing This Unit

1. *Halstead Copper Products* (pamphlet). Greensboro, NC: Halstead, 1994.
2. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.
3. *Paxton/Patterson Graves-Humphreys Catalog 93.* Chicago, IL: Paxton/Patterson, 1993.
4. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1993.
5. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

The Imperial Eastman Company of Chicago manufactures tubing tools of all kinds and has an excellent 20-minute video tape production showing how to use the tubing tools that are popular in ACR service. The video tape is free to instructors who would like to use it. To order, call 708-285-6123, or FAX your request to 708-285-6178. Be sure to specify the video production *Tubing Tools Training, a Video Presentation.*

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Tubing and Tubing Applications
Unit 5

Answers to Assignment Sheet 1

Assignment Sheet 1

Evaluate according to criteria written in the assignment sheet. Answers will vary with fittings selected and their order.

Tubing and Tubing Applications
Unit 5

Answers to Written Test

1. a. 5
   b. 11
   c. 13
   d. 7
   e. 9
   f. 1
   g. 8
   h. 10
   i. 3
   j. 6
   k. 2
   l. 12
   m. 4

2. a. 2
   b. 4
   c. 1
   d. 3

3. a. the jobsite
   b. stronger
   c. thermal conductivity
   d. corrosion

4. a. green, green
   b. severe corrosion
   c. walked on

5. a. blue, blue
   b. medium-thick
   c. air conditioning applications

6. a. red, red
   b. i.d.
   c. low

7. a. yellow, yellow
   b. thin

8. a. 4
   b. 5
   c. 8
   d. 10
   e. 2
   f. 7
   g. 9
   h. 6
   i. 1
   j. 11
   k. 3

9. a. Seal cap or bonnet
   b. Gasket
   c. Cross
   d. Union elbow
   e. Male-to-female elbow
   f. Reducing union elbow
   g. Male-to-swivel elbow

Answers to Written Test

h. Short nut
i. Long nut
j. Cap nut
k. Cap
l. Nut-heavy pattern
m. Plug
n. Union tee
o. Small-to-large reducing tee
p. Large-to-small reducing tee
q. Union
r. Male-to-female union
s. Female union
t. Female-to-male tee
u. Reducing union
v. Male-to-female reducer
w. Swivel

10. a. Male elbow
b. 45° elbow
c. Pipe-to-flare-to-flare-tee
d. Flare-to-flare-to-pipe-tee
e. Female connector
f. Connector

11. a. Ferrule or sleeve
b. Nut
c. Union
d. Compression-to-pipe connector
e. Union elbow
f. Union tee
g. Compression-to-female flare connector
h. Compression-to-female flare elbow

12. a. Coupling
b. Reducer coupling
c. 180° return bend
d. P-trap or suction line trap
e. 90° elbow
f. 45° elbow
g. Street elbow
h. Cap
i. Tee
j. Sweat-to-pipe
k. Sweat-to-flare
l. Sweat-to-flare swivel

Answers to Written Test

13. a. 13
    b. 1
    c. 2

14. a, b, d

15. a. chamfered
    b. tools, tool
    c. compression
    d. Rol-Air
    e. ⅓
    f. base
    g. work hardened

16. a, b, e

17. b, c, d, e, h

Tubing and Tubing Applications
Unit 5

Written Test

Name ______________________________ Date ______________ Score _____

1. Match the terms on the right with their correct definitions. Definitions are continued on the next page.

______a. Tubing heat treated to make it ductile enough for easy bending

______b. A tubing prepared especially for ACR applications; it is free of contaminants, sealed to stay that way, and measured by its outside diameter

______c. A beveled recess; used interchangeably with the word "bevel"

______d. A tubing connector that has a nut, sleeve-ring, and union

______e. Drain, waste, vent, a tubing classification for noncritical service lines

______f. A 45° cone-shaped enlargement made at the end of a piece of tubing so that it will form a lip to hold a flare nut and provide a mating surface between a nut and a beveled fitting

______g. A type of tubing that should not be bent

______h. A tubing made for use with water lines, drains, and other applications, but not made for use with refrigerant lines; it is measured by its inside diameter

______i. Bends in a tube spaced at intervals that cause the tube to bend away from and then back to a starting line or angle

1. Flare
2. Sweat
3. Offset
4. Quick connect
5. Annealed tubing
6. Stretch
7. Compression fitting
8. Hard drawn
9. DWV
10. Nominal-size tubing
11. ACR tubing
12. Washout
13. Chamfer

______j. The tendency of a tube to increase in length in relation to the degree to which it is bent

______k. A method of joining tubing and fittings by manipulating melted filler material into and around a heated joint

______l. An area where a piece of tubing becomes extremely thin because a flaring tool has been overtightened

______m. A type of fitting that permits refrigerant lines to be connected or disconnected rapidly

2. Match kinds of tubing with their applications. Place the number beside the tubing name in the blank beside the description of its application.

______a. A tubing type that is free of contaminants, sealed, and measured by outside diameter; it is used almost exclusively for ACR applications

______b. A tubing type measured by inside diameter and not designed for use in ACR applications; it is used in water drains, vents, and other noncritical applications

______c. A tubing type used on the evaporator and suction lines of some refrigerators, and for parts of central air conditioning condensers, and for some automotive air conditioning lines

______d. A tubing type used with liquid lines and other lines in compression refrigeration, domestic refrigeration condensers, some evaporators, and all lines in absorption refrigeration

1. Aluminum tubing
2. ACR copper tubing
3. Steel tubing
4. Nominal-size copper tubing

Written Test

3. Complete statements about the advantages of copper tubing in ACR applications. Circle the material that best completes each of the following statements.

   a. Copper tubing is easy to bend and flare, characteristics that make it ideal for the turns required in many installations and for tailor making flare connections on (**gas lines**) (**the jobsite**).

   b. Copper tubing is easy to solder and braze in applications where (**stronger**) (**larger**) connections are required.

   c. Copper tubing has a high (**thermal conductivity**) (**heat retention value**) for maintaining temperatures of both hot and cold lines.

   d. Copper tubing can be installed in almost all service conditions because it has a high resistance to (**wear**) (**corrosion**).

4. Complete statements about type K copper tubing and its applications. Circle the material that best completes each of the following statements.

   a. Type K tubing is color coded with a (**green**) (**blue**) box and a (**green**) (**blue**) tag.

   b. Type K tubing has a heavy, thick wall and is used for applications where self-support is vital and in applications subjected to (**vibration**) (**severe corrosion**).

   c. Type K tubing is often installed in areas where foot traffic or other abnormal use will require tubing strong enough to be (**jarred**) (**walked on**) or strong enough to stand the weight of something placed onto it.

5. Complete statements about characteristics of type L copper tubing and its applications. Circle the material that best completes each of the following statements.

   a. Type L tubing is color coded with a (**green**) (**blue**) box and a (**green**) (**blue**) tag.

   b. Type L tubing has a (**medium-thick**) (**thin**) wall and is used for underground water service where coils are permitted, coils for hydronic heating systems, and returns for water heating or condensate lines.

   c. Type L tubing is the most often used tubing type in (**air conditioning applications**) (**heating applications**).

Written Test

6. Complete statements about characteristics of type M copper tubing and its applications. Circle the material that best completes each of the following statements.

   a. Type M tubing is color coded with a (**blue**) (**red**) box and a (**blue**) (**red**) tag.

   b. Type M tubing is medium-thin wall tubing used for underground water service, water distribution systems and chilled water systems for up to 1″ (**i.d.**) (**o.d.**).

   c. Type M tubing is also used for hot water heating and (**low**) (**high**) pressure system applications up to 1¼″ i.d.

7. Complete statements about characteristics of DWV tubing and its applications. Circle the material that best completes each of the following statements.

   a. DWV tubing is color coded with a (**red**) (**yellow**) box and a (**red**) (**yellow**) tag.

   b. DWV tubing has a (**thin**) (**thick**) wall and is often used on drain waste pipes.

8. Match tubing fittings with their characteristics. Place the number beside the type of fitting in the blank beside the description of its characteristic. Descriptions are continued on the next page.

______a. A female fitting used to close off the end of a piece of tubing

______b. A fitting that connects two pieces of tubing together

______c. A fitting that is female on both ends

______d. A fitting used to make turns in tubing lines, always assumed to be 90° unless otherwise stated

______e. The female end of a two-piece threaded connector

______f. A male fitting used to close off the end of a piece of tubing

______g. A fitting used to change from one size to another

1. Street ell
2. Nut
3. Union
4. Cap
5. Connector
6. Seal cap
7. Plug
8. Coupling
9. Reducer/increaser
10. Elbow or ell
11. Tee

Written Test

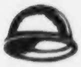
______h. A piece of copper used to convert a nut to a cap

______i. An ell fitting that is male on one end and female on the other

______j. A fitting that branches a tubing line so that it has two outlets at a given point; the branch size and type is listed first, then the left outlet, then the right outlet

______k. A connector that can be removed without disturbing the two pieces of tubing it connects

9. Identify flare fittings. Place the name of the fitting in the blank below its illustration.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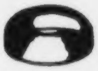
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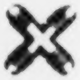
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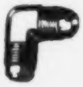
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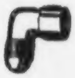
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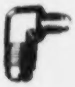
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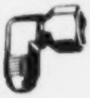
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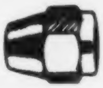
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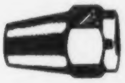
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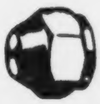
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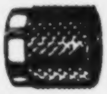
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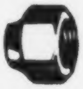
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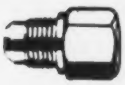
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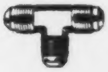
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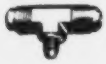
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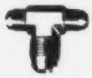
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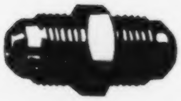
Written Test



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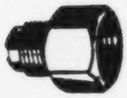

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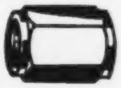
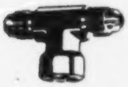


s. ______________



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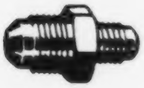
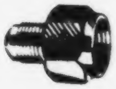


u. ______________



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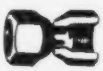
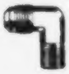


w. ______________

10. Identify flare-to-pipe fittings. Write the name of the fitting in the blank below its illustration.



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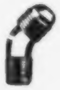

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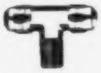

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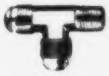

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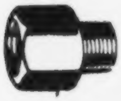

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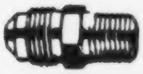
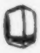


f. ______________

11. Identify compressing fittings. Write the name of the fitting in the blank below its illustration.



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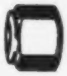

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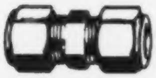

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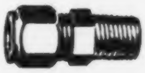
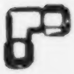
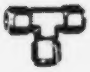
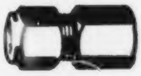
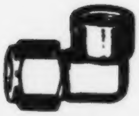


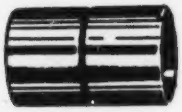
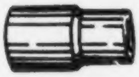
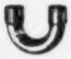
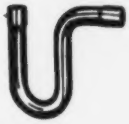
d. ______________

Written Test

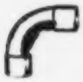
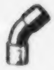
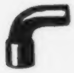
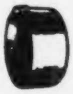





e. __________ f. __________ g. __________ h. __________

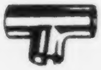
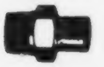
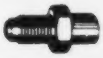
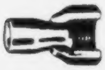
12. Identify sweat fittings. Write the name of the fitting in the blank below its illustration.

a. __________ b. __________ c. __________ d. __________

e. __________ f. __________ g. __________ h. __________

i. __________ j. __________ k. __________ l. __________

Written Test

13. Match quick connect fittings with their applications. Place the number beside the fitting type in the blank beside its description.

______a.	Installed on precharged refrigerant lines so that a built-in knife cuts a blocking diaphragm to permit refrigerant flow at installation, but the line connection will not close again if the line is ever disconnected	1.	Spring-loaded seal
______b.	Installed on precharged refrigerant lines so that a spring is depressed to permit refrigerant flow at installation, and the spring closes if the line is ever disconnected	2.	Compression seal
______c.	Installed with a special ferrule secured by a female nut, and the types designed for ACR applications are so marked	3.	Cutter-type seal

14. Select true statements about guidelines for cutting and reaming tubing. Place an "X" beside each true statement.

______a. To operate a tubing cutting tool, mark the cut line clearly, then turn the ratchet-type handle so that the cutting wheels cut deeply into the tubing so they will stay in place.

______b. Turn the cutter clockwise around the tubing in a slow, steady turn until you feel the cutting wheels start to move too freely; stop at that point and turn the cutter handle until the wheels tighten again, then repeat the turning, tightening motion until you have a clean cut through the tubing.

______c. Tighten the wheels onto the tubing as tight as you can to insure a quick, clean cut.

______d. Ream the end of the cut tubing with the reaming tool attached to the cutter or with a knife or file, but be as careful reaming as you are cutting so you will keep the end of the pipe clean and round.

Written Test

15. Complete statements about guidelines for flaring tubing. Circle the material that best completes each of the following statements.

    a. Flaring blocks are built with (**chamfered**) (**threaded**) insets made in various sizes to facilitate various sizes of tubing.

    b. Flaring (**spindles**) (**tools**) fit over flaring blocks and clamp onto them so that the (**tool**) (**spindle**) can be screwed into the open end of the tubing to press the tubing against the chamfered inset of the flaring block.

    c. A (**compression**) (**generating**) flaring block is made so that the tubing barely extends above the block, and the flaring tool screws down to spread the end of the tubing out evenly, and the 45° flare is made inside the block.

    d. A (**Rol-Air®**) (**compression**) flaring block is made so that the tubing extends far enough above the block that the flare itself is made above the block; this eliminates the possibility of scoring the tubing at the base of the flare, and provides a high burnish that facilitates a tighter, stronger fit.

    e. Place the tubing in the flaring block so that it extends above the block a distance equal to (⅓) (½) the diameter of tubing for sizes up to ½", and a slightly smaller extension for tubing sizes larger than ½".

    f. Do not overtighten the flaring tool as it presses the tubing against the chamfer wall; overtightening can cause the flare to split or produce score marks at the (**lip**) (**base**) of the flare.

    g. Overtightening can also cause a flare to become (**work hardened**) (**brittle**), meaning that the tubing will lose strength and be unfit for use.

16. Select true statements about guidelines for swaging tubing. Place an "X" beside each true statement.

    _______a. Making a swage joint on copper or aluminum also requires a flaring block and a special tool called a swage punch which can be tapped into the tubing or a swage tool that screws down into the tubing much like a flaring device.

    _______b. To make a good swage joint, start with clean cut tubing that has been properly reamed; make sure the tubing extends up far enough from the flaring block to reach the turn of the shoulder on the swaging tool.

    _______c. Place the flaring block in a vise, and begin guiding the swage punch into the tubing.

Written Test

______d. Lightly tap the hammer to get the swage punch started and then continue to lightly hammer the swage punch to the proper depth into the tubing; use heavy hammer blows if the punch seems to bind.

______e. When you use a swage punch that screws into the tubing, work the punch in without overtightening and make sure it goes in to the proper depth.

______f. Swage joints are common for both soldered and brazed joints in ACR service, and when the joints are properly formed and joined, they provide secure connections only for horizontal joints.

17. Select true statements about tools for bending tubing. Place an "X" beside each true statement.

______a. For tubing lines that are going to be subjected to pressure and vibration, the fewer the connection the better, and bending tubing helps provide the long tubing runs that provide a very cosmetic job.

______b. Trying to bend tubing without a tool will almost always cause the tubing to flatten out at the point of the bend, and such a restriction in a line could impair system performance.

______c. The "old standby" for bending tubing is the spring bender; slide it over the tubing, apply pressure, and bend the tubing to the desired angle.

______d. The spring bender gets the job done once you get the "knack" of it, but the lever-type bender is easier to work with because the tubing bends around a grooved center point much like a rope moving through a pulley.

______e. The lever-type bender is more exact because the centerpiece is marked in degrees that match bend marks on the upper operating lever so that tubing can be bent to any degree including 45°, 90°, and a complete turn of 180°.

______f. Lever-type benders are available for different sizes of tubing, so pick the bender that is within at least ½" of the tubing size with which you're working.

______g. Tubing, especially copper has a tendency to stretch when it bends; in fact, the rule is that copper tubing will stretch about two times the tubing diameter for each 90° of bend.

______h. The tendency for copper to stretch when it bends means that critical measurements have to figure in the "bend allowance" and cut the piece shorter than the actual length desired.

***Permission to duplicate this test is granted.**

Tubing and Tubing Applications
Unit 5

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Identify Selected Fittings for Copper Tubing Rating ______

Comments: ______________________

____

Job Sheet 1—Make a Single Flare With a Compression-Type Flaring Block Rating ______

Comments: ______________________

____

Job Sheet 2—Make a Single Flare With a Rol-Air®-Type Flaring Block Rating ______

Comments: ______________________

____

Job Sheet 3—Make a Swage Joint in Copper Tubing Rating ______

Comments: ______________________

____

Job Sheet 4—Make a 90° Bend in Copper Tubing Rating ______

Comments: ______________________

____

Job Sheet 5—Make a 180° Bend in Copper Tubing Rating ______

Comments: ______________________

____

Unit Evaluation Form

Job Sheet 6—Make a 45° Offset Bend in Copper Tubing Rating ______

Comments: ____

____

Other ____

____

Written Tests: Pretest ______ Posttest ______

Total ______

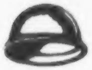
Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

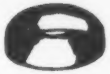
*Permission to duplicate this form is granted.

Flare Fittings

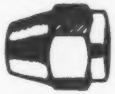
Seal Cap



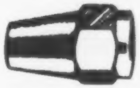
Gasket



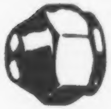
Short Nut



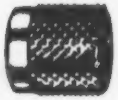
Long Nut



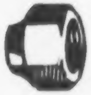
Cap Nut



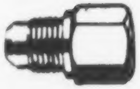
Flare Cap



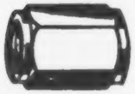
Nut-Heavy Pattern



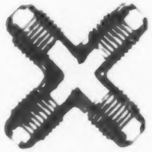
Plug



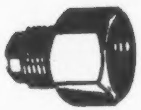
Female Union



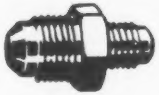
Cross



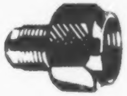
Male-to-Female Connector



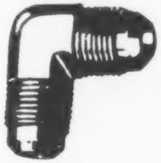
Reducing Union



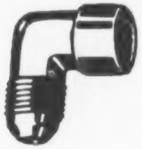
Male-to-Female Reducer



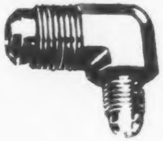
Union Elbow



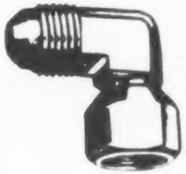
Male-to-Female Elbow



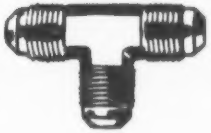
Reducing Union Elbow



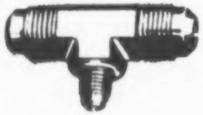
Male-to-Female Swivel Elbow



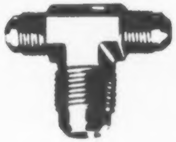
Union Tee



Small-to-Large Reducing Tee



Large-to-Small Reducing Tee



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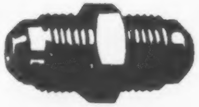
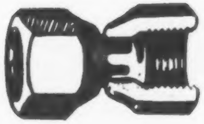
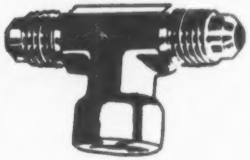


Swivel



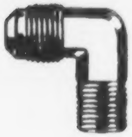
Female-to-Male Tee



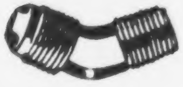
Flare-to-Pipe and Compression Fittings

Flare-to-Pipe Fittings

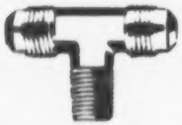
Male Elbow



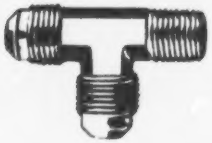
45° Male Elbow



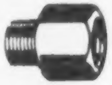
Pipe-to-Flare-to-Flare Tee



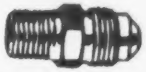
Flare-to-Flare-to-Pipe Tee



Flare-to-Pipe Connector



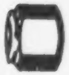
Pipe-to-Flare Connector



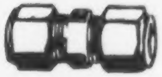
Compression Fittings

Sleeve

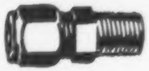
Nut



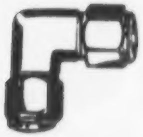
Union



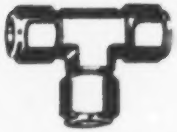
Compression-to-Pipe Connector



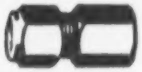
Union Elbow



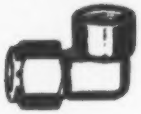
Union Tee



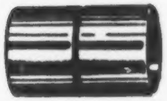
Compression-to-Female-Flare Connector

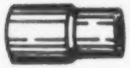


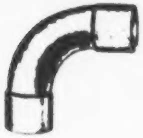
Compression-to-Female-Flare Elbow

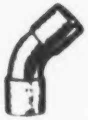


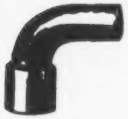
Sweat Fittings

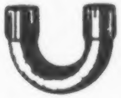

Coupling

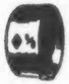

Reducer Coupling

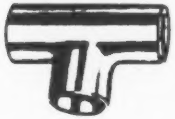

90° Elbow

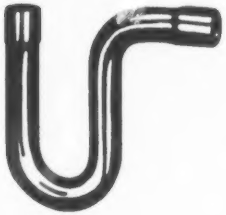

45° Elbow

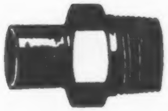

Street Elbow

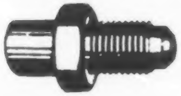

180° Return Bend

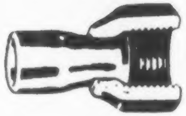

Cap


Tee


P-Trap or
Suction Line Trap

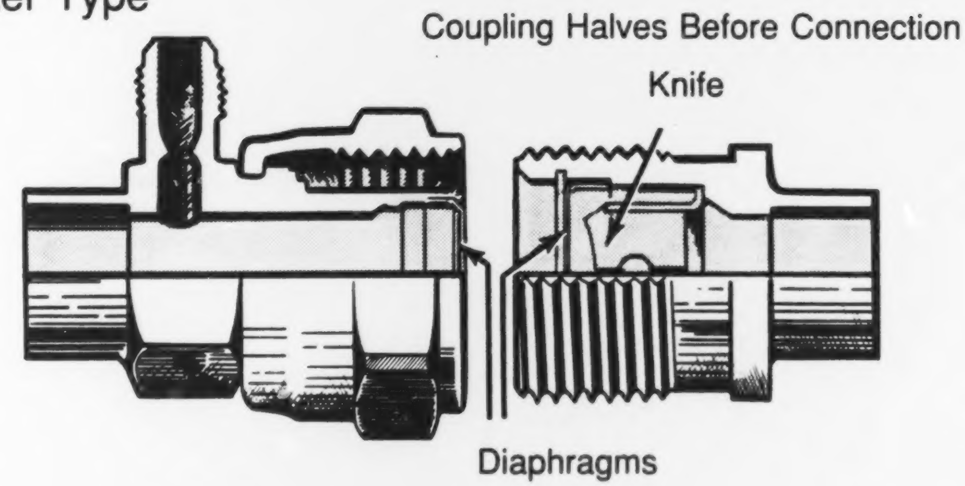

Sweat-to-Pipe


Sweat-to-Flare

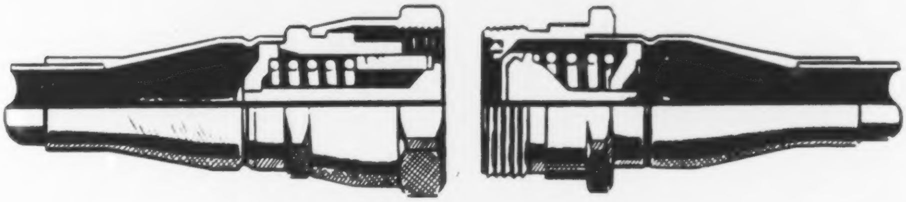

Sweat-to-Flare Swivel

Quick-Connect Fittings

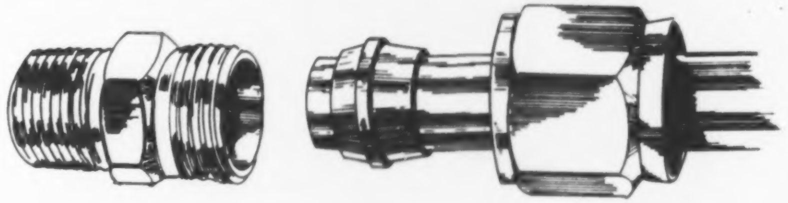
Cutter Type


Coupling Halves Before Connection
Knife
Diaphragms

Spring Loaded Seal



Compression Type



Tubing and Tubing Applications
Unit 5

Information Sheet

1. **Terms and definitions**

   a. **Annealed tubing** — Tubing heat treated to make it ductile enough for easy bending

   b. **ACR tubing** — A tubing prepared especially for ACR applications; it is free of contaminants, sealed to stay that way, and measured by its outside diameter

   c. **Chamfer** — A beveled recess; used interchangeably with the word "bevel"

   d. **Compression fitting** — A tubing connector that has a nut, sleeve-ring, and union

   e. **DWV** — Drain, waste, vent, a tubing classification for noncritical service lines

   f. **Flare**— A 45° cone-shaped enlargement made at the end of a piece of tubing so that it will form a lip to hold a flare nut and provide a mating surface between a nut and a beveled fitting

   g. **Hard drawn** — A type of tubing that should not be bent

   h. **Nominal-size tubing** — A tubing made for use with water lines, drains, and other applications, but not made for use with refrigerant lines; it is measured by its inside diameter

   i. **Offset** — Bends in a tube spaced at intervals that cause the tube to bend away from and then back to a starting line or angle

   j. **Stretch** — The tendency of a tube to increase in length in relation to the degree to which it is bent

   k. **Sweat** — A method of joining tubing and fittings by manipulating melted filler material into and around a heated joint

   l. **Washout**— An area where a piece of tubing becomes extremely thin because a flaring tool has been overtightened

   m. **Quick connect** — A type of fitting that permits refrigerant lines to be connected or disconnected rapidly

Information Sheet

2. **Kinds of tubing and their applications**

   a. **ACR copper tubing** — A tubing type that is free of contaminants, sealed, and measured by outside diameter; it is used almost exclusively for ACR applications

   b. **Nominal size copper tubing** — A tubing type measured by inside diameter and not designed for use in ACR applications; it is used in water drains, vents, and other noncritical applications

   c. **Aluminum tubing** — A tubing type used on the evaporator and suction lines of some refrigerators, and for parts of central air conditioning condensers, and for some automotive air conditioning lines

   d. **Steel tubing** — A tubing type used with liquid lines and other lines in compression refrigeration, domestic refrigeration condensers, some evaporators, and all lines in absorption refrigeration

3. **Advantages of copper tubing in ACR applications**

   a. Copper tubing is easy to bend and flare, characteristics that make it ideal for the turns required in many installations and for tailor making flare connections on the jobsite.

   b. Copper tubing is easy to solder and braze in applications where stronger connections are required.

   c. Copper tubing has a high thermal conductivity for maintaining temperatures of both hot and cold lines.

   d. Copper tubing can be installed in almost all service conditions because it has a high resistance to corrosion.

4. **Characteristics of type K copper tubing and its applications**

   a. Type K tubing is color coded with a green box and a green tag.

   b. Type K tubing has a heavy, thick wall and is used for applications where self-support is vital and in applications subjected to severe corrosion.

   c. Type K tubing is often installed in areas where foot traffic or other abnormal use will require tubing strong enough to be walked on or strong enough to stand the weight of something placed onto it.

Information Sheet

5. **Characteristics of type L copper tubing and its applications**

    a. Type L tubing is color coded with a blue box and a blue tag.

    b. Type L tubing has a medium-thick wall and is used for underground water service where coils are permitted, coils for hydronic heating systems, and returns for water heating or condensate lines.

    c. Type L tubing is used for most potable water applications including water fountains and ice makers, and in general, type L tubing is the most often used tubing in ACR applications.

6. **Characteristics of type M copper tubing and its applications**

    a. Type M tubing is color coded with a red box and a red tag.

    b. Type M tubing is medium-thin wall tubing used for underground water service, water distribution systems and chilled water systems for up to 1" i.d.

    c. Type M tubing is also used for hot water heating and low pressure system applications up to 1¼" i.d.

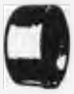
7. **Characteristics of DWV tubing and its applications**

    a. DWV tubing is color coded with a yellow box and a yellow tag.

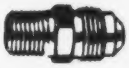
    b. DWV tubing has a thin wall and, as the initials imply, is often used on drains, vents, and waste pipes.

8. **Tubing fittings and their characteristics**

    a. **Cap** — A female fitting used to close off the end of a piece of tubing

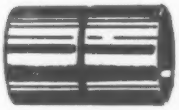


    b. **Connector** — A fitting that connects two pieces of tubing together

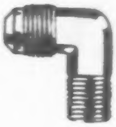


Information Sheet

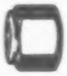
c. **Coupling** — A fitting that is female on both ends



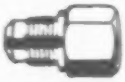
d. **Elbow or ell** — A fitting used to make turns in tubing lines, always assumed to be 90° unless otherwise stated



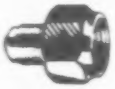
e. **Nut** — The female end of a two-piece threaded connector



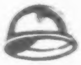
f. **Plug** — A male fitting used to close off the end of a piece of tubing



g. **Reducer/increaser** — A fitting used to change from one size to another

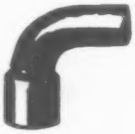


h. **Seal cap** — A piece of copper used to convert a nut to a cap



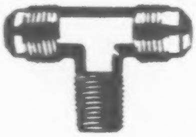
Information Sheet

i. **Street ell** — An ell fitting that is male on one end and female on the other

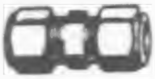


j. **Tee**— A fitting that branches a tubing line so that it has two outlets at a given point; the branch size and type is listed first, then the left outlet, then the right outlet

Note: Fittings are almost always listed left end first by type and size and then right end.

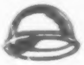


k. **Union**— A connector that can be removed without disturbing the two pieces of tubing it connects

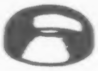


9. **Flare fittings**

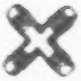
a. Seal cap or bonnet



b. Gasket

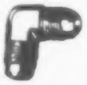


c. Cross

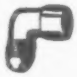


Information Sheet

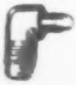
d. Union elbow



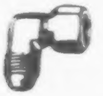
e. Male-to-female elbow



f. Reducing union elbow

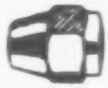


g. Male-to-female swivel elbow

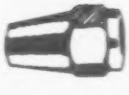


h. Short nut

Note: Short nuts are also made with slits that keep them from loosening because of expansion or contraction, and they are also known as "frost-free."

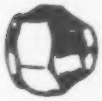


i. Long nut

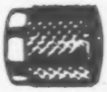


Information Sheet

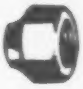
j. Cap nut



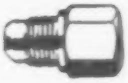
k. Cap



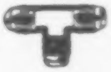
l. Nut-heavy pattern



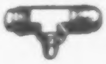
m. Plug



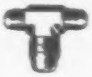
n. Union tee



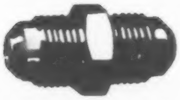
o. Small-to-large reducing tee (also called a "branch reducer")



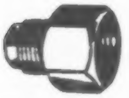
p. Large-to-small reducing tee (also called a "bullhead")



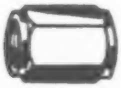
q. Union



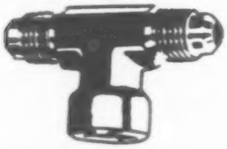
r. Male-to-female union



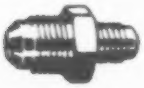
s. Female union



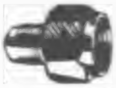
t. Female-to-male tee



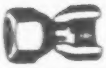
u. Reducing union



v. Male-to-female reducer



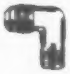
w. Swivel



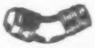
Information Sheet

10. **Flare-to-pipe fittings or half unions**

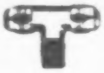
    a. Male elbow



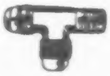
    b. 45° elbow



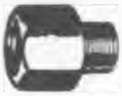
    c. Pipe-to-flare-to-flare tee



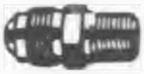
    d. Flare-to-flare-to-pipe tee



    e. Female connector



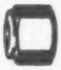
    f. Connector



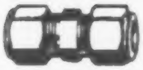
11. **Compression fittings**

    a. Ferrule or sleeve

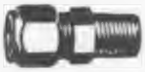
b. Nut



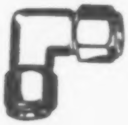
c. Union



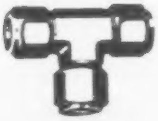
d. Compression-to-pipe connector



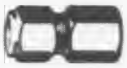
e. Union elbow



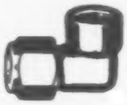
f. Union tee



g. Compression-to-female-flare connector



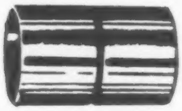
h. Compression-to-female flare elbow



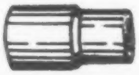
Information Sheet

12. **Sweat fittings**

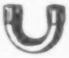
a. Coupling



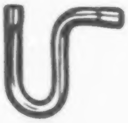
b. Reducer coupling



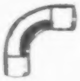
c. 180° return bend



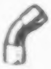
d. P-trap or suction line trap



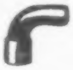
e. 90° elbow (available with long or short bend radius)



f. 45° elbow



g. Street elbow (available with long or short bend radius)



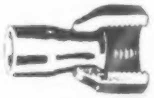
h. Cap

i. Tee

j. Sweat-to-pipe

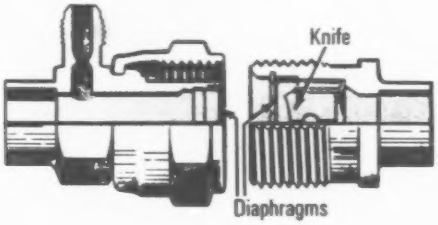
k. Sweat-to-flare

l. Sweat-to-flare swivel



13. **Quick connect fittings and their applications**

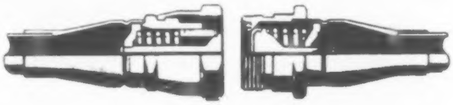
a. **Cutter-type seal** — Installed on precharged refrigerant lines so that a built-in knife cuts a blocking diaphragm to permit refrigerant flow at installation, but the line connection will not close again if the line is ever disconnected



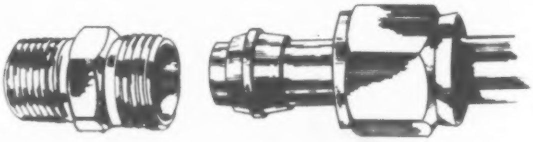
Information Sheet

b. **Spring-loaded seal** — Installed on precharged refrigerant lines so that a spring is depressed to permit refrigerant flow at installation, and the spring closes if the line is ever disconnected

Note: Spring-loaded seals are typically used on mobile home installations, but they can be used anywhere.



c. **Compression seal** — Installed with a special ferrule secured by a female nut, and the types designed for ACR applications are so marked



14. Guidelines for cutting and reaming tubing

a. To operate a tubing cutting tool, mark the cut line clearly, then turn the ratchet-type handle so that the cutting wheels cut deeply into the tubing so they will stay in place.

b. Turn the cutter clockwise around the tubing in a slow, steady turn until you feel the cutting wheels start to move too freely; stop at that point and turn the cutter handle until the wheels tighten again, then repeat the turning, tightening motion until you have a clean cut through the tubing.

c. Don't tighten the wheels onto the tubing too tight because this will cause the end of the tubing to bend.

d. Ream the end of the cut tubing with the reaming tool attached to the cutter or with a knife or file, but be as careful reaming as you are cutting so you will keep the end of the pipe clean and round.

Information Sheet

15. Guidelines for flaring tubing

a. Flaring blocks are built with chamfered insets made in various sizes to facilitate various sizes of tubing.

b. Flaring tools fit over flaring blocks and clamp onto them so that the tool can be screwed into the open end of the tubing to give it the desired flare.

c. A compression flaring block is made so that the tubing barely extends above the block, and the flaring tool screws down to spread the end of the tubing out evenly, and the 45° flare is made inside the block.

d. A Rol-Air® flaring block is made so that the tubing extends far enough above the block that the flare itself is made above the block; this eliminates the possibility of scoring the tubing at the base of the flare, and provides a high burnish that facilitates a tighter, stronger fit.

e. Place the tubing in the flaring block so that it extends above the block a distance equal to ⅓ the diameter of tubing for sizes up to ½", and a slightly smaller extension for tubing sizes larger than ½".

Information Sheet

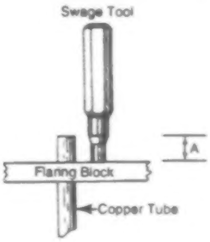
f. Do not overtighten the flaring tool as it presses the tubing against the chamfer wall; overtightening can cause the flare to split or produce score marks at the base of the flare.

g. Overtightening can also cause a flare to become work hardened, meaning that the tubing will lose strength and be unfit for use.

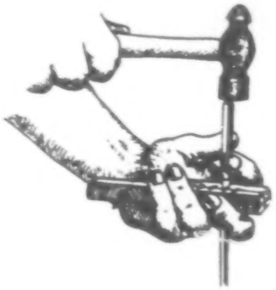
16. Guidelines for swaging tubing

a. Making a swage joint on copper or aluminum also requires a flaring block and a special tool called a swage punch which can be tapped into the tubing or a swage tool that screws down into the tubing much like a flaring device.

b. To make a good swage joint, start with clean cut tubing that has been properly reamed; make sure the tubing extends up far enough from the flaring block to reach the turn of the shoulder on the swaging tool.



c. Hold the flaring block in the palm of your hand with your thumb and index finger guiding the swage punch into the tubing.

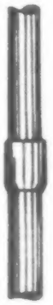


d. Lightly tap the hammer to get the swage punch started and then continue to lightly hammer the swage punch to the proper depth into the tubing, but do not make heavy blows with the hammer.

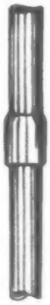
Information Sheet

e. When you use a swage punch that screws into the tubing, work the punch in without overtightening and make sure it goes in to the proper depth.

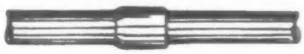
f. Swage joints are common for both soldered and brazed joints in ACR service, and when the joints are properly formed and joined, they provide excellent connections for upright, inverted, and horizontal joints.



Upright



Inverted



Horizontal

17. **Tools for bending tubing**

a. For tubing lines that are going to be subjected to pressure and vibration, the fewer the connections the better, and bending tubing helps provide the long tubing runs that provide better service.

b. Trying to bend tubing without a tool will almost always cause the tubing to flatten out at the point of the bend, and such a restriction in a line could upset system performance.

Information Sheet

c. The "old standby" for bending tubing is the spring bender; slide it over the tubing, apply pressure, and bend the tubing to the desired angle.

d. The spring bender gets the job done once you get the "knack" of it, but the lever-type bender is easier to work with because the tubing bends smoothly around a grooved center designed to help the tubing retain its "round."

e. The lever-type bender is more exact because the centerpiece is marked in degrees that match bend marks on the upper operating lever so that tubing can be bent to any degree including 45°, 90°, and a complete turn of 180°.

f. Lever-type benders are available for different sizes of tubing, so pick the bender for the tubing size with which you're working.

Information Sheet

g. Tubing, especially copper has a tendency to stretch when it bends; in fact, the rule is that copper tubing will stretch about one times the tubing diameter for each 90° of bend.

Example: If you put a 90° bend in $^3/_8$″ copper tubing, the tubing should stretch about $^3/_8$″. If you put a 45° bend in $^3/_8$″ copper tubing, the tubing should stretch about half of $^3/_8$″ or $^3/_{16}$″.

h. The tendency for copper to stretch when it bends means that critical measurements have to figure in the "bend allowance" and cut the piece shorter than the actual length desired.

Tubing and Tubing Applications
Unit 5

Assignment Sheet 1—Identify Selected Fittings for Copper Tubing

Name ______________________ Overall Rating __________

Evaluation Criteria	Rating
Number of fittings presented for identification	______
Number of fittings properly identified	______
Percentage or ratio of success	______

Directions: Your instructor has selected a random assortment of various types of fittings used for working with copper tubing in ACR applications. Each fitting is tagged with a number. Identify each fitting by its general class and by its specific name. For instance, if the fitting is a "Flare" fitting, also list whether it is a tee, a reducer, or whatever it happens to be.

Fitting 1 (general class): ______________ Specific Name: ______________

Fitting 2 (general class): ______________ Specific Name: ______________

Fitting 3 (general class): ______________ Specific Name: ______________

Fitting 4 (general class): ______________ Specific Name: ______________

Fitting 5 (general class): ______________ Specific Name: ______________

Fitting 6 (general class): ______________ Specific Name: ______________

Fitting 7 (general class): ______________ Specific Name: ______________

Fitting 8 (general class): ______________ Specific Name: ______________

Fitting 9 (general class): ______________ Specific Name: ______________

Fitting 10 (general class): ______________ Specific Name: ______________

Note: If your instructor has selected more than 10 fittings, add the number along with your definitions on the back of this page.

Tubing and Tubing Applications
Unit 5

Job Sheet 1—Make a Single Flare With a Compression-Type Flaring Block

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Tubing properly cut and reamed	______
Flare smooth and polished	______
Flare fit checked on seat of flare nut	______

A. Tools and materials

Tubing cutter w/reamer
Compression-type flaring block
Flaring tool
Tape measure or rule
Refrigeration oil
³⁄₈″ soft-role copper tubing and one ³⁄₈″ flare nut

B. Procedure

☐ 1. Put on safety glasses.

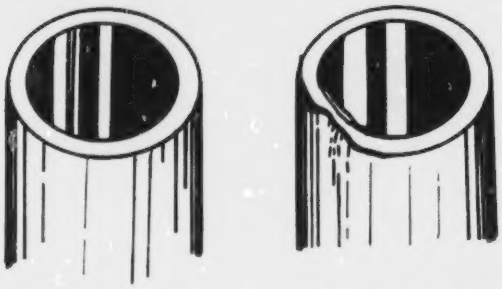
☐ 2. Unroll and unseal selected tubing and straighten it out so that it is at least 6″ longer than the piece you will need, then measure and mark a piece 6″ long.

☐ 3. Place the cutter on the tubing, and gently tighten the cutter in place.

☐ 4. Turn the cutter around the pipe a couple of times and then tighten the cutter slightly.

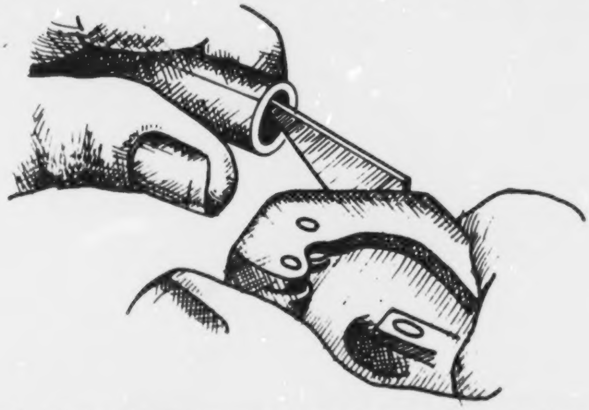
Job Sheet 1

☐ 5. Continue turning and tightening the cutter a bit at a time in order to avoid bending the end of the tubing.



☐ 6. Finish the cut, remove the tools, and reseal the end of the tubing.

☐ 7. Ream the end of the cut tubing just enough to remove the burr, but do not overream.



☐ 8. Point the end of the tubing down as you ream so the metal particles will fall out.

> **Caution: Do not blow into the pipe; moisture contaminates copper.**

☐ 9. Place tubing in the flaring block so that it extends above the block ⅓ the diameter of the tubing for sizes up to ½″ and slightly less for larger sizes.

☐ 10. Place a drop of refrigeration oil on the treads of the flaring tool and spread another drop around the cone of the flaring tool, but be sure to use only refrigeration oil when working with refrigeration system components.

☐ 11. Tighten the cone into the tubing about two turns, then back it out.

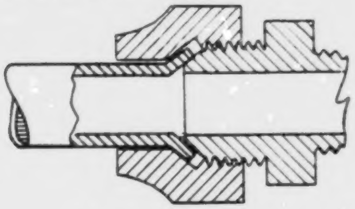
Job Sheet 1

☐ 12. Continue the tightening and loosening procedure until the flare is completed, but do not overtighten flaring tool or it may wash out or even split the flare.

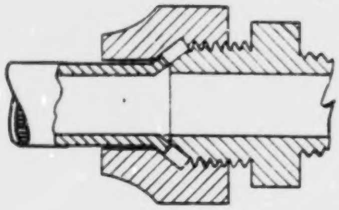
☐ 13. Loosen flaring tool and remove the tubing from the flaring block.

☐ 14. Visually inspect for a smooth, polished flare with a 45° chamfer and no evidence of work hardening.

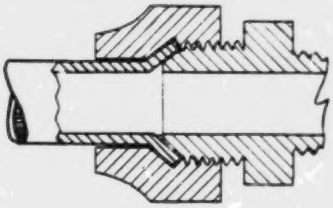
☐ 15. Make a final inspection by fitting a flare nut onto the flare and checking for an even, smooth fit.



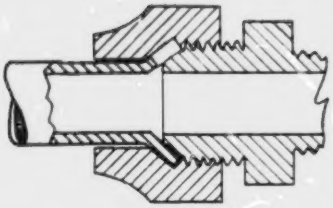
Properly Made Flare



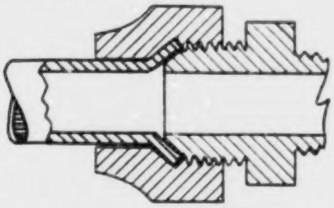
Flare Too Small



Flare Too Large



Flare is Uneven



Tubing was Not Reamed Before Flaring

☐ 16. Have your instructor check your work.

☐ 17. Keep tubing for the next job sheet.

Evaluator's comments: ____________________

____

____

Tubing and Tubing Applications
Unit 5

Job Sheet 2—Make a Single Flare With a Rol-Air®-Type Flaring Block

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Tubing properly cut and reamed	______
Flare smooth and polished	______
Flare fit checked on seat of flare nut	______

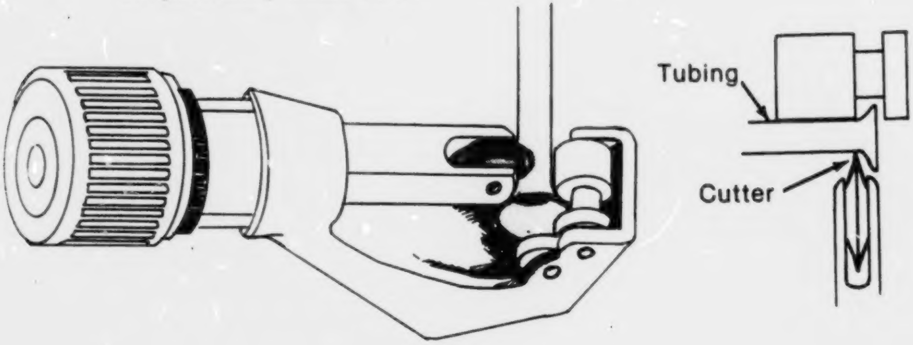
A. Tools and materials

Tubing cutter w/reamer and slot cutter rollers
Rol-Air®-type flaring block
Flaring tool
Refrigeration oil
Copper tubing cut and flared in Job Sheet 1
Flare nut used in Job Sheet 1
Safety glasses

B. Procedure

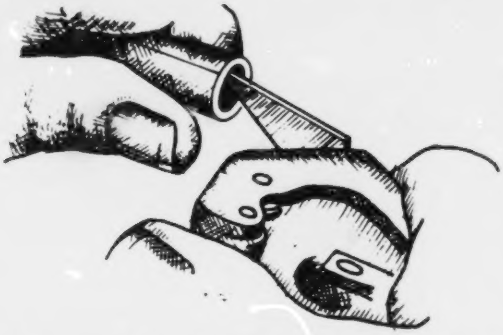
☐ 1. Put on safety glasses.

☐ 2. Place the flare made in Job Sheet 1 into the slot cutter rollers and cut off the previously made flare.



Job Sheet 2

☐ 3. Ream out the burrs from the end of the tubing.

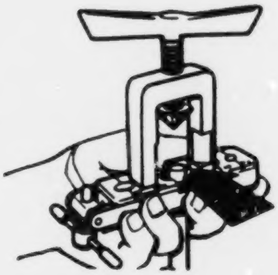


☐ 4. Be careful not to overream and to point the end of the tubing down so metal particles will fall out.

☐ 5. Place tubing in the flaring block.

☐ 6. Place the flaring tool on the block and use the portion of the flaring tool below the slot as a height gauge to tell you how far beyond the block to extend the tubing.

Note: How far up to extend the tubing varies by the type of flaring tool you are using. If you have a guide available follow instructions from the manufacturer.



☐ 7. Put a drop of refrigeration oil on the threads and cones of the flaring tool.

☐ 8. Tighten the cone into the tubing a couple of turns and then back it out.

☐ 9. Continue the process until the flare is completed.

☐ 10. Remove the flaring tool and remove the tubing from the flaring block.

☐ 11. Visually inspect for a smooth, polished flare with no evidence of work hardening.

Job Sheet 2

☐ 12. Make a final inspection by fitting a flare nut onto the flare and checking for an even, smooth fit.

☐ 13. Have your instructor check your work.

☐ 14. Keep tubing for the next job sheet.

Evaluator's comments: ____

____

____

Tubing and Tubing Applications
Unit 5

Job Sheet 3—Make a Swage Joint in Copper Tubing

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

Evaluation criteria	**Rating**
Swage height properly measured	______
Swage punch properly used	______
Swage joint smooth and to proper depth	______

A. Tools and materials

Tubing cutter w/reamer
Compression-type flaring block
$\frac{3}{8}$" swage punch
$\frac{3}{8}$" copper tubing from Job Sheet 2
Small ball peen hammer for tubing
Refrigeration oil
Retractable measuring rule
Safety glasses

B. Procedure

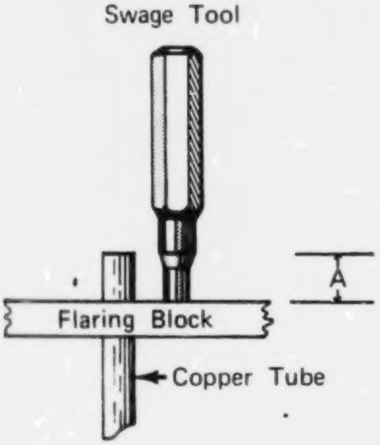
☐ 1. Put on safety glasses.

☐ 2. Place the tubing in the compression-type flaring block; do not use a generating-type block.

☐ 3. Adjust the height of the tubing so that the depth of the swage will be equal to the diameter of the tubing plus $\frac{1}{16}$ of an inch, or in this case, $\frac{7}{16}$ of an inch.

Job Sheet 3

☐ 4. Check the distance by placing the punch adjacent to the tubing.

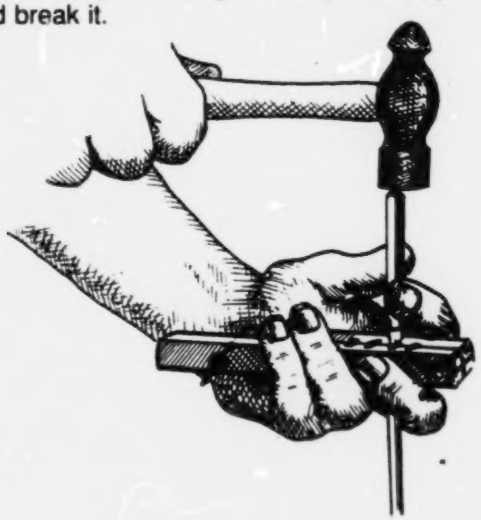


☐ 5. Place a small amount of refrigerant oil on the upper part of the swage punch.

☐ 6. Hold the block in your hand firmly so that the tubing extends below the block between your second and third finger.

☐ 7. Guide the swage punch with your thumb and index finger above the block.

Note: It's important to guide the punch so you will not hit it at an off angle and break it.



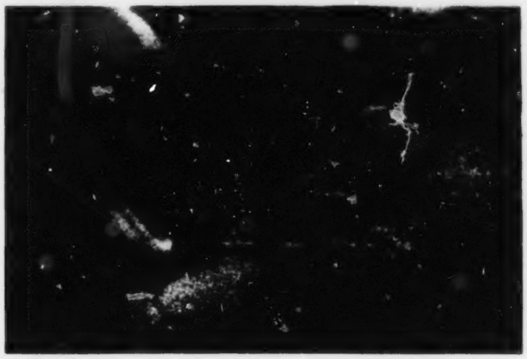
Job Sheet 3

☐ 8. Lightly tap the punch to start it into the tubing, then use light blows to hammer it on into the tubing until it forms the tubing above the block into a cup-like swage.

Caution: Do not hammer against the body of the swage tool.

☐ 9. Remove the punch by twisting it back and forth.

☐ 10. Check to see if the extra piece of $3/8$" o.d. tubing will fit into the swage in a close fit.



☐ 11. Have your instructor check your work.

☐ 12. Keep tubing for later activities.

Evaluator's comments: ______________________________

____

____

Tubing and Tubing Applications
Unit 5

Job Sheet 4—Make a 90° Bend in Copper Tubing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Tubing properly cut and reamed	______
Tubing properly placed and aligned in bender	______
Tubing bend free of flat spots	______

A. Tools and materials

Tubing cutter w/reamer
⅜″ lever-type bender
⅜″ o.d. soft drawn copper tubing
Retractable tape measure
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Unseal a roll of copper tubing, and straighten the roll so that it is at least 6″ longer than what you need.

☐ 3. Measure and cut off the 17″ piece, then reseal the roll of tubing immediately, and proceed to ream the end of the piece you cut off.

☐ 4. Measure 7″ on the end of the tubing where you intend to make the bend, and mark the spot clearly so it will be easy to reference.

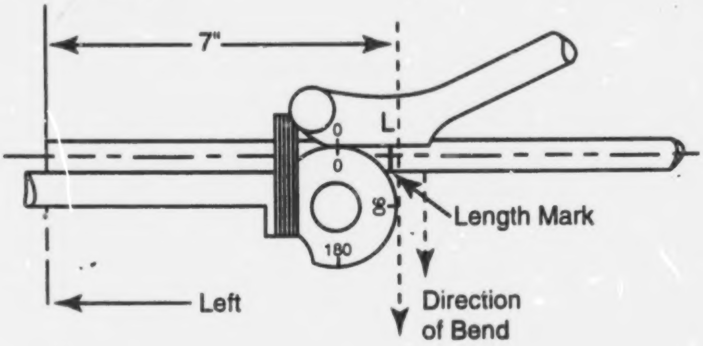
☐ 5. Place the bender on the tubing, and ask your instructor for help if you have trouble placing the tubing.

☐ 6. Align the bending handle of the bender so that the zero mark on the handle is in line with the 0° mark on the bender degree gauge.

Note: Multiple size benders may have slightly different reference marks.

Job Sheet 4

☐ 7. Align the L mark on the bender with the 7″ reference mark you made on the tubing.



☐ 8. Pull the bending lever down with a steady force until the 0 mark aligns with the 90° mark on the bender degree gauge.

☐ 9. Remove the tubing from the bender.

☐ 10. Measure from the 7″ reference mark to the end of the bend to see if the tubing has stretched just a little.

Note: The tubing should have stretched approximately $^3/_8$″ because as a general rule, copper tubing will stretch about one times the tube diameter for each 90° bend.

☐ 11. Have your instructor check your work.

☐ 12. Return the bender to proper storage and save the tubing for later activities.

Evaluator's comments: ______________________________

____

____

Tubing and Tubing Applications
Unit 5

Job Sheet 5—Make a 180° Bend in Copper Tubing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Tubing properly cut and reamed	______
Tubing properly placed and aligned in bender	______
Tubing bend free of flat spots	______

A. Tools and materials

Tubing cutter w/reamer
⅜″ lever-type bender
⅜″ o.d. soft drawn copper tubing
Retractable tape measure
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Unseal a roll of copper tubing, and straighten the roll so that it is at least 6″ longer than what you need.

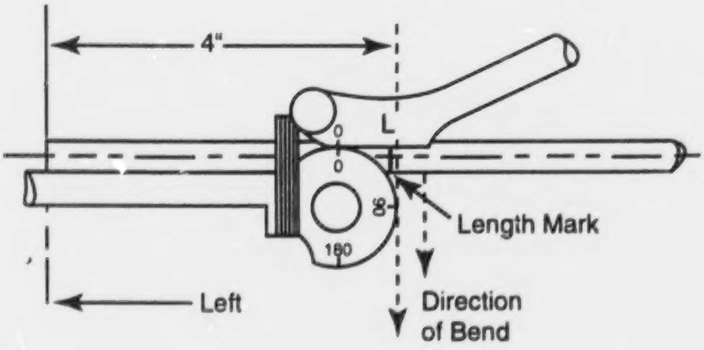
☐ 3. Measure and cut off the 17″ piece, reseal the roll of tubing immediately, and proceed to ream the end of the piece you cut off.

☐ 4. Measure 4″ on the end of the tubing where you intend to make the bend, and mark the spot clearly so it will be easy to reference.

☐ 5. Place the bender on the tubing, and ask your instructor for help if you have questions about placing the tubing properly.

☐ 6. Align the bending handle of the bender so that the zero mark on the handle is in line with the 0° mark on the bender degree gauge.

☐ 7. Align the L mark on the bender with the 4″ reference mark you made on the tubing.



☐ 8. Pull the bending lever down with a steady force until the 0 mark aligns with the 180° mark on the bender degree gauge.

☐ 9. Remove the tubing from the bender.

☐ 10. Measure from the 4″ reference mark to the end of the bend to see if the tubing has stretched just a little.

Note: The tubing should have stretched approximately ⅝″ or ¾″ because as a general rule, copper tubing will stretch about one times the tube diameter for each 90° bend.

☐ 11. Have your instructor check your work.

☐ 12. Return the bender to proper storage and save the tubing for later activities.

Evaluator's comments: ____

____

____

Tubing and Tubing Applications
Unit 5

Job Sheet 6—Make a 45° Offset Bend in Copper Tubing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Tubing stretch properly identified	______
Tubing bent to specified offsetting angles	______
Tubing bend free of flat spots	______

A. Tools and materials

Tubing cutter w/reamer
⅜″ lever-type bender
⅜″ o.d. soft drawn copper tubing
Retractable tape measure
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Unseal roll of copper tubing, and straighten the roll so that it is at least 6″ longer than what you need.

☐ 3. Measure and cut off a 20″ piece, reseal the roll or tubing immediately, and proceed to ream the end of the piece you cut off.

☐ 4. Measure 6″ on the end of the tubing where you intend to make the bend, and mark the spot clearly so it will be easy to reference.

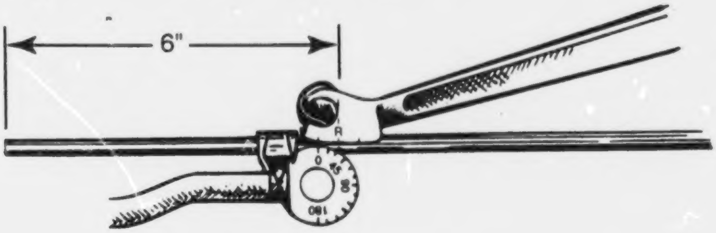
☐ 5. Place the bender on the tubing, and ask your instructor for help if you have questions about placing the tubing properly.

☐ 6. Align the bending handle of the bender so that the zero mark on the handle is in line with the 0° mark on the bender degree gauge.

☐ 7. Align the R mark on the bender with the 6″ reference mark you made on the tubing.

Job Sheet 6

☐ 8. Pull the bending lever down with a steady force until the 0 mark aligns with the 45° mark on the bender degree gauge.



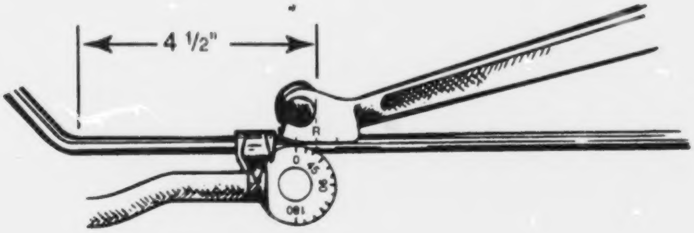
☐ 9. Remove the tubing from the bender.

☐ 10. Measure 4½" from the first reference mark, and mark the tubing again.

☐ 11. Place the bender on the opposite side of tubing from the previous bend.

☐ 12. Align the R mark on the bender with the second reference mark on the tubing.

☐ 13. Pull the lever until the 0 mark on the tubing aligns with the 45° mark on the bender gauge.



☐ 14. Remove the tubing from the bender and check for proper offset bends.

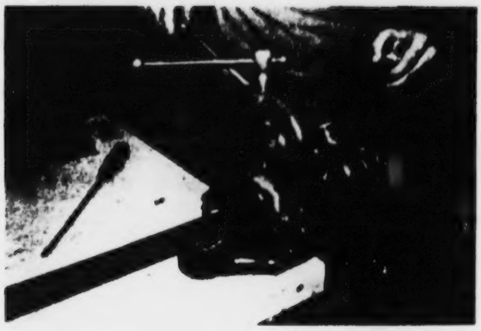
☐ 15. Have your instructor check your work, and write in the following blank how far you think the tubing stretched in this activity: ____________

☐ 16. Save tubing for later activities.

Evaluator's comments: ____

____

____



Iron, Plastic, and PVC Pipe
Unit 6

Objective Sheet

Unit Objective

After completing this unit, the student should be able to cut and ream PVC pipe and join it to a fitting; cut, ream, and thread iron pipe, and join flexible plastic pipe with a butt fusion process. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to iron, plastic, and PVC pipe with their correct definitions.
2. Complete statements about black iron in HVAC applications.
3. Select true statements about galvanized pipe in HVAC applications.
4. Complete statements about polybutylene and polyethylene in HVAC applications.
5. Solve problems about guidelines for using iron pipe fittings.
6. Select true statements about guidelines for using brass fittings.
7. Select true statements about guidelines for using flexible plastic fittings.
8. Select true statements about guidelines for using PVC fittings.
9. Complete statements about guidelines for working with polybutylene and polyethylene.
10. Complete statements about using PE dielectric unions in HVAC applications.
11. Solve problems about guidelines for measuring pipe.
12. Select true statements about tools for cutting and threading iron pipe.
13. Explain in your own words what a pipe threading chart shows.

Objective Sheet

14. Select true statements about tools for working with PVC.
15. Cut and ream PVC pipe and join it to a fitting. (Job Sheet 1)
16. Cut, ream, and thread iron pipe. (Job Sheet 2)
17. Join flexible plastic pipe with a butt fusion process. (Job Sheet 3)

Iron, Plastic, and PVC Pipe
Unit 6

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make a transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with objectives as indicated.

   TM 1—Iron Pipe Fittings (Objective 4)
   TM 2—Brass Fittings (Objective 5)
   TM 3—Flexible Plastic Pipe Fittings (Objective 6)
   TM 4—PVC Fittings (Objective 7)
   TM 5—Tools for Cutting and Threading Iron Pipe (Objective 9)
   TM 6—Tools for Making PVC Joints (Objective 11)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Suggested Activities

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Impress upon students the value of having skills in working with black iron and galvanized pipe. These skills overlap with other trades such as plumbing, but they also expand a students ability to work with that other part of the AC industry, heating. In other words, the "H" in HVAC means "heating" and skills in heating applications truly make a technician more employable. Skill areas: **Learning skills, learning to learn.**

2. Introduction of flexible plastic pipe starts with Objective 4, but its treated again in Objective 9. Try to find a company in your area that is working with ground-source heat pumps and using polybutylene or polyethylene in those applications. Find out what fusion methods are used in your area, and although a butt fusion procedure is outlined in Job Sheet 3, it would be extremely effective if you can find a local company that is using socket fusion and could demonstrate it to the class. Skill areas: **Learning skills, learning to learn.**

3. For Objective 10, try to find a complete service HVAC company in the area, one that installs and services heating. Also, ask a local gas company representative to talk to students about the use of polyethylene in gas service. Skill areas: **Learning skills, learning to learn.**

4. When you're discussing Objective 11 with the class, point out that the "thread engagement allowance" functions with copper tubing and fittings just as well as with iron pipe fittings. Of course, with tubing, the allowance is a "sweat allowance" not a "thread allowance." Students should make it a habit to make such allowances when working with any kind of pipe or tubing that require fittings. Skill areas: **Foundation skills, math.**

Suggested Activities

5. When you discuss Objective 12, show any other pipe cutting tools you have available, including tripods and power threaders. The tools shown in the objective are the typical low-cost tools carried on a service vehicle, and a student needs to know how to use them. Skill areas: **Foundation skills, math and science.**

Resources Used In Developing This Unit

1. *Central Plastics Catalog*. Shawnee, OK: Central Plastics Company, 1993.
2. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.
3. *Nibco Plastic Plumbing Products Catalog*. Elkhart, IN: Nibco, Inc., 1994.
4. *Paxton/Patterson Graves-Humphreys Catalog 93*. Chicago, IL: Paxton/Patterson, 1993.
5. *Rigid Catalog No RT-191*. Elyria, OH: Ridge Tool Company, 1991.
6. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994.
7. *Vanguard Geo-Products*. McPherson, KS: Vanguard Plastics, Inc., 1994.
8. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1. *Water to Water Heat Pump/Hydronic Radiant Heating and Cooling Systems Applications and Equipment Guidelines* is available from Vanguard Plastics, Inc. at 831 Vanguard Street, Wichita, KS 67460, or 316-241-6369. The same product and installation guide is also available from InFloor Heating Systems at 920 Hamel Road, Hamel, MN 55340 or 612-478-6072. The booklet provides an interesting look into several HVAC applications for flexible plastic pipe.

2. *Closed-Loop/Geothermal Heat Pump Systems, Design, and Installation Standards* is available from the International Ground-Source Heat Pump Association at Oklahoma State University. Information is available by phone at 1-800-626-4747, or you can write:

   International Ground-Source Heat Pump Association
   490 Cordell South
   OSU
   Stillwater, OK 74078

Suggested Activities

3. *Pipe Cutters* and *Pipe Threaders* are VHS video productions made by the Ridge Tool Company. The videos are about 15 minutes long and contain especially valuable information about how cutting and threading tools are made, and how they should be used and maintained. Tapes are free, but Ridge does request you make copies and return the originals. Write to:

   Ridge Tool Company
   400 Clark Street
   Elyria, OH 44036-2023

   or call the Ridge Tool company at (216) 323-5581 and ask for the Advertising Department.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Iron, Plastic, and PVC Pipe
Unit 6

Answers to Written Test

1. a. 5
   b. 12
   c. 2
   d. 7
   e. 10
   f. 4
   g. 1
   h. 9
   i. 3
   j. 13
   k. 6
   l. 11
   m. 8

2. a. LPG gas
   b. compressed air lines
   c. steam
   d. galvanized

3. a, b

4. a. Flexible
   b. earth-coupled
   c. most
   d. heat fusion
   e. 500
   f. Higher density
   g. Yellow

5. a. (1)
   b. (3)

6. b, c, d, f

7. a

8. b, d

9. a. computer
   b. flexible
   c. Butt fusion
   d. Socket fusion, socket fusion
   e. Sidewall fusion
   f. Electronic
   g. PB and PE

Answers to Written Test

10. a. copper
    b. metals
    c. grounding connections
    d. loosen
    e. several

11. a. (3)
    b. (2)

12. a, b, e

13. Explanation should include:

    A pipe threading chart may list the number of threads per inch, but it also relates pipe diameter to approximate length of the threads to be cut and the approximate number of threads to be cut so a tape measure can be used to verify proper threading.

14. a, b, c, d

Iron, Plastic, and PVC Pipe
Unit 6

Written Test

Name ______________________________ Date ________________ Score ______

1. Match the terms on the right with their correct definitions.

______a. A thick, lead-base paste applied to pipe threads to seal a joint

______b. The chemical reaction caused by an electric current passing through certain metals which act as an electrolyte in the presence of earth cover or dissimilar metals

______c. Female pipe threads

______d. To coat iron with zinc in order to prevent rusting

______e. A manually operated in-line shut-off valve in a gas line

______f. Wrought iron or steel pipe

______g. Male pipe threads

______h. Any piece of pipe 12 inches or less in length

______i. Not suitable for drinking

______j. National pipe taper thread, a standard for deep-V pipe threads prepared to taper $\frac{1}{16}$" in diameter for every inch of thread length

______k. Polybutylene, flexible plastic pipe and tubing used in low-pressure applications with nonpotable water lines

______l. Polyethylene, flexible plastic pipe and tubing used in ground-coupled heat pump applications and for gas lines

______m. A tape applied to pipe threads to help seal a joint and fight corrosion

1. MPT
2. FPT
3. Nonpotable
4. Long pipe
5. Dope
6. PB
7. Galvanize
8. Teflon tape
9. Nipple
10. Gas cock
11. PE
12. Electrolysis
13. NPT

Written Test

2. Complete statements about black iron pipe in HVAC applications. Circle the material that best completes each of the following statements.

   a. Black iron pipe is traditionally used for piping natural gas or (**LPG gas**) (**oil**) to furnaces.

   b. Black iron pipe is used for some (**compressed air lines**) (**high-pressure water lines**).

   c. Black iron pipe is used for both chilled liquid lines and for (**steam**) (**water supply**) lines as well as other hydronic heat applications.

   d. Black iron pipe is painted black to help it fight rust and corrosion, to make it easy to distinguish from (**galvanized**) (**unpainted**) iron pipe, and wrought iron and steel pipe, often called long pipe.

3. Select true statements about galvanized pipe in HVAC applications. Place an "X" beside each true statement.

   ______a. Galvanized pipe is coated with zinc to help it resist rusting, and is used on all kinds of water-carrying lines such as chilled water lines and ice-maker water lines.

   ______b. Galvanized pipe is also used on water-cooled condenser supply and return lines and on condensate lines.

   ______c. Galvanized pipe should be used for gas lines only if local codes approve.

4. Complete statements about polybutylene and polyethylene in HVAC applications. Circle the material that best completes each of the following statements.

   a. (**Flexible**) (**Rigid**) plastic tubing and pipes made of PB and PE are being used more and more in a variety of HVAC applications.

   b. PB and PE have long been used for plumbing lines in manufactured homes, but their applications extend over a wide range of HVAC services such as hydronic radiant floor heating, fire sprinkler systems, irrigation systems, and (**earth-coupled**) (**air-to-air**) heat pump loops.

   c. PB and PE resist (**all**) (**most**) chemicals, they are both resistant to electrolysis and corrosion, and they even resist ultra violet degradation; the expected service life of both PB and PE is set at 50 years plus.

   d. PB tubing is highly flexible, lightweight, and easy to clamp into place, so it is used for applications such as condensate lines and nonpotable water service; PB and PE pipe can be joined with (**welding**) (**heat fusion**) processes that make service-free connections.

e. PB and PE are both used in ground-coupled heat pump applications, and because they are available in large rolls of up to (**100**) (**500**) feet, they can be installed in connection-free long runs that minimize service needs.

f. (**Higher density**) (**Heavier**) polyethylene is used for gas transport lines because it resists corrosion and most chemicals and has other service characteristics that make it a more practical application than metal tubing or pipe.

g. (**Yellow**) (**Purple**) is the international color used to indicate pipe or tubing used for gas lines, but American-made polyethylene may be black, tan, orange, or other colors; the international (**yellow**) (**purple**) color is being phased into American production.

5. Solve problems about guidelines for using iron pipe fittings. Circle the number beside the statement that best solves each of the following problems.

   a. You and a fellow worker are making up a run of black iron pipe to an elbow and the fellow worker starts tightening the bare pipe into the elbow. To solve the problem, you should:

      (1) Put some dope or teflon tape on the pipe thread so it will make up properly and be protected from corrosion.

      (2) Oil the threads on the pipe end so they will make up easier.

      (3) Brush the threads with a stainless steel brush to make sure they are clean.

   b. You have been given the job of joining a galvanized pipe to a piece of black pipe and you notice you have a plain union. To solve the problem, you should:

      (1) Put plenty of dope on both sides of the union when you make it up to the pipe.

      (2) Get a heavier union because the two different types of pipe require heavier connections.

      (3) Get an insulated union with dielectric characteristics because this is a requirement for joining galvanized pipe to any other kind of pipe.

6. Select true statements about guidelines for using brass fittings. Place an "X" beside each true statement.

   ______a. Use brass fittings for copper and aluminum pipe only.

   ______b. Make up brass fittings with dope or Teflon tape, except for connections that have bevels for use with flare nuts.

Written Test

______c. Use pure copper saddle valves for takeoffs from copper water supply lines; these are common sources for water to refrigerator ice makers.

______d. Use flexible gas connectors from a gas supply line to a gas valve only when you know they are permitted by local codes.

______e. Make sure flexible gas connectors have dielectric characteristics; if a connector is not tagged with a "dielectric" notification, ground it to a safe ground before you use it.

______f. Use other brass fittings for general service applications such as change-direction connections, extensions, and reductions.

7. Select true statements about guidelines for using flexible plastic fittings. Place an "X" beside each true statement.

______a. Use plastic fittings for connections on flexible plastic pipe and for hard aluminum pipe.

______b. Insert a fitting into pipe or tubing and seal it with solvent cement.

8. Select true statements about guidelines for using PVC fittings. Place an "X" beside each true statement.

______a. Use PVC fittings on PVC, CPVC, or ABS plastic pipe.

______b. When making up unthreaded joints on PVC or CPVC pipe, use primer before applying solvent cement.

______c. When making up threaded PVC joints, use Teflon tape or pipe dope.

______d. Confine pressure testing to low-pressure air supplies, but do not use compressed air to check a PVC line or fitting.

9. Complete statements about guidelines for working with polybutylene and polyethylene. Circle the material that best completes each of the following statements.

a. Both PB and PE can be joined mechanically with clamps or can be fused together with a heat/fusion process using an electric heater, a torch, or a special (**computer**) (**heating mold**).

b. Because PB is more rubbery and (**flexible**) (**stretchable**) than PE, PB tubing is used for a lot of nonpotable water line, drains, or condensate lines where tubing can be mechanically clamped onto couplings or other fittings.

c. (**Butt fusion**) (**Socket fusion**) is used on both PB and PE; it is a process where tubing ends are butted against each other and fused together to create a long run of connection-free tubing, a desired condition for earth-coupled heat pump loops.

d. (**Socket fusion**) (**Butt fusion**) requires special hand tools for placing fittings onto tubing for making turns or creating service access; (**socket fusion**) (**butt fusion**) is used on heat pump loops and especially on gas line applications where service tees and other fittings are common.

e. (**Socket fusion**) (**Sidewall fusion**) also requires tools for tapping into a line and making a tee; this application permits a service entrance to be placed onto a gas main so the entrance to a residence can be tapped into at a later date as needed.

f. (**Electrical**) (**Electronic**) fusion uses a portable computer and other special equipment to fuse tubing and to evaluate the quality of the connection, all in one procedure; computer verification of joint quality is to assure a service-free connection.

g. All of the fusion processes used with (**PB and PE**) (**any plastic pipe**) require a technician be trained and certified in the processes.

10. Complete statements about guidelines for using PE dielectric unions in HVAC applications. Circle the material that best completes each of the following statements.

a. Dielectric unions are required to isolate hot water heater tanks from (**copper**) (**polyethylene**) tubing; the manufacturer's warranty is invalid if the proper union is not installed.

b. Dielectric protection is required because of the problem that arises when two dissimilar (**metals**) (**materials**) are joined together in the presence of water; the condition creates an electric current that promotes electrolysis and galvanic corrosion; in fact, the presence of heat speeds the corrosive process.

c. Dielectric unions also stop the flow of stray electrical currents which may be picked up from nearby electrical lines or appliance (**grounding connections**) (**interference**).

d. Dielectric unions made of nylon insulated malleable iron are ideal protection devices because they not only provide the dielectric protection, but have added service characteristics that will not corrode or (**break**) (**loosen**) under strain or vibration.

e. Dielectric unions have (**minimal**) (**several**) air conditioning applications, and also for related service areas such water pumps, water conditioners, steam lines, fan coil units, finned tube radiation and convectors, and for gas piping in heating applications.

Written Test

11. Solve problems about guidelines for measuring pipe. Circle the number beside the statement that best solves each of the following statements.

    a. You have to cut and thread a piece of pipe that has to be made up with a fitting on each end. To avoid having a piece of pipe too short or too long you should:

        (1) Measure the total length of each fitting first.

        (2) Measure the pipe a little long so if you do make a mistake you'll have enough pipe to correct your error; if you cut it too short, you don't get a second try.

        (3) Measure to see how far into each fitting the pipe will go, then add that amount for thread engagement.

    b. You are putting a take-off together and you know there is some rule about making a measurement. To solve your problem, you should:

        (1) Make a center-to-center measurement and then subtract one side.

        (2) Make an end-to-center measurement from the end of the pipe to the center of the takeoff fitting.

        (3) Make a center-to-center measurement and then add about 1" to be sure you are safe.

12. Select true statements about tools for cutting and threading iron pipe. Place an "X" beside each true statement.

    ______a. When a single pipe or only a few pieces of pipe have to be cut, a hand-held pipe cutter is a favorite tool because it is relatively inexpensive, highly portable, and easy to use.

    ______b. Just like copper tubing, once a pipe has been cut, the end has to be reamed and this can be done with a hand-operated reamer.

    ______c. Any vise will do for holding pipe as long as the jaws of the vise aren't worn to the point where the pipe will slip.

    ______d. The special die used for threading pipe gives the pipe straight threads, and the die stock secures the die and makes the threading an easy job.

    ______e. An oil can is a must for cutting and threading pipe because the threads must be oiled with special sulphur-based cutting oil at almost every turn to control heat and avoid damage to the die and pipe; a catch pan for catching oil is also a required pipe cutting/threading tool.

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Written Test

13. Explain in your own words what a pipe threading chart shows.

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14. Select true statements about tools for working with PVC. Place an "X" beside each true statement.

______a. Straight 90° cuts on PVC can be made with a miter box and a saw, but a PVC cutter takes less time and usually provides a cleaner cut.

______b. A knife is required for cutting and trimming, and a knife with a retractable blade is probably safer to handle and transport.

______c. PVC cleaner is required to prepare the pipe for joining, and a clean, cotton shop cloth is needed for cleanup.

______d. PVC cement is required for joining the pipe to fittings or for joining fittings to fittings.

______e. Applying PVC cement requires a regular size paint brush.

***Permission to duplicate this test is granted.**

Iron, Plastic, and PVC Pipe
Unit 6

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Job Sheet 1—Cut and Ream PVC Pipe and Join it to a Fitting Rating ______

Comments: ______________________

____

Job Sheet 2—Cut, Ream, and Thread Iron Pipe Rating ______

Comments: ______________________

____

Job Sheet 3—Join Flexible Plastic Pipe With a Butt Fusion Process Rating ______

Comments: ______________________

____

Other ______________________

____

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

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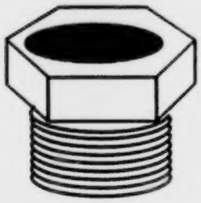
*Permission to duplicate this form is granted.

Iron Pipe Fittings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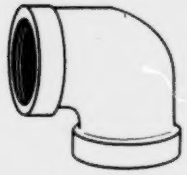
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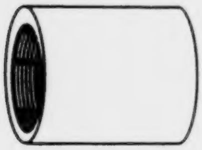
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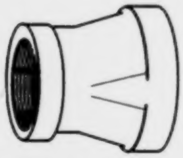
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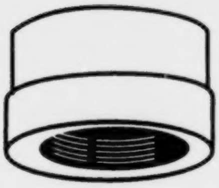
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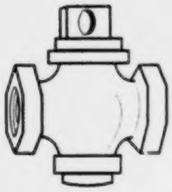
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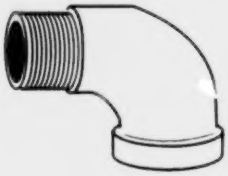
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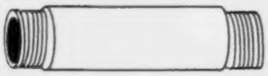
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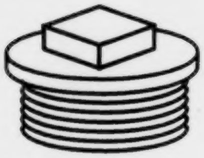
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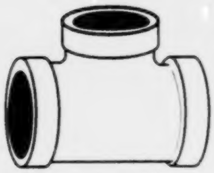
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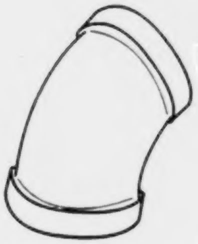
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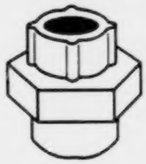
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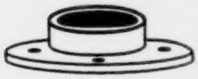
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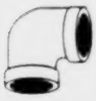
Brass Fittings



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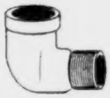

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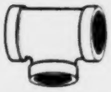

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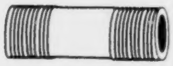

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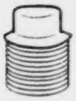

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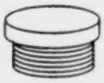

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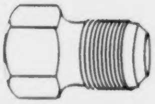

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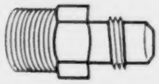

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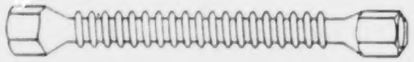

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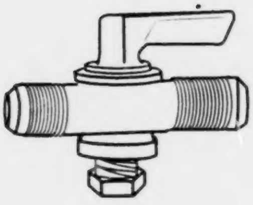

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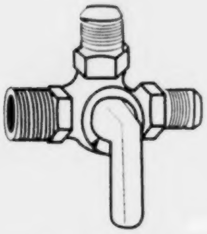

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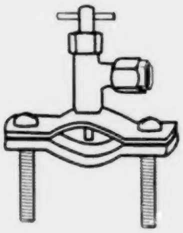
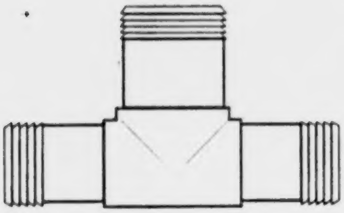


Saddle Valve

Flexible Plastic Pipe Fittings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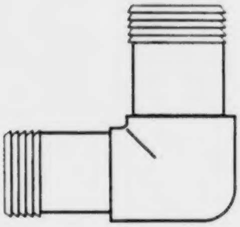
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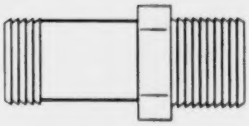
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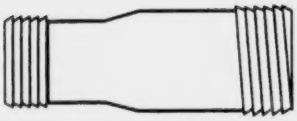
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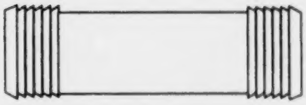
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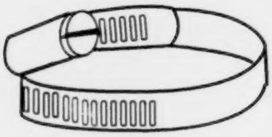
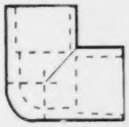

Clamp

P.V.C. Fittings



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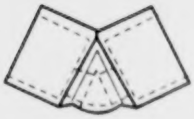

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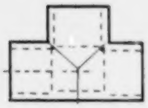

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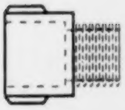

Male Adapter
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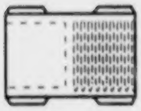

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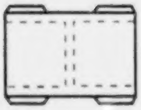
or FPT



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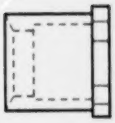

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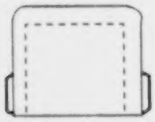

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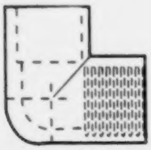
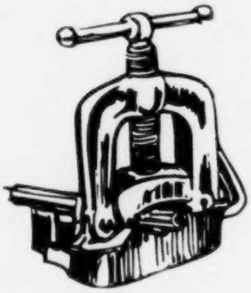
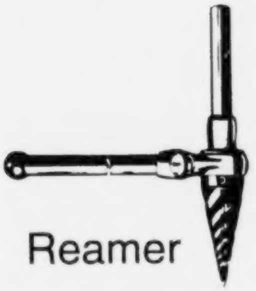


90° Ell
P.V.C. to FPT

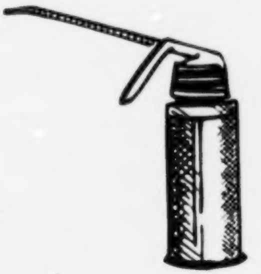
Tools For Cutting and Threading Iron Pipe



Pipe Vise



Reamer



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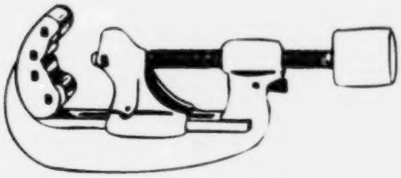

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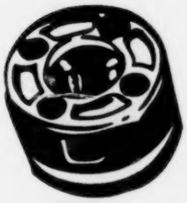

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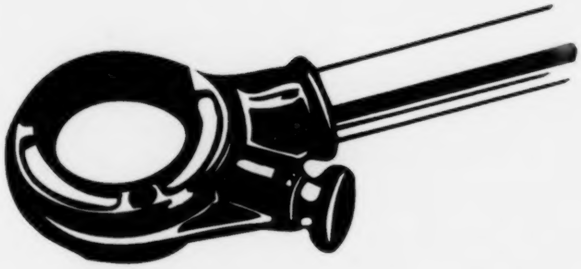
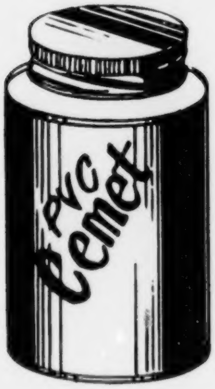
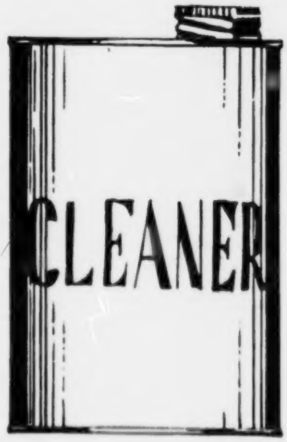


Die Stock

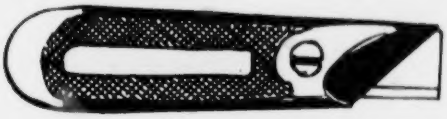
Tools for Making P.V.C. Joints



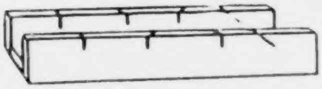
P.V.C Cement



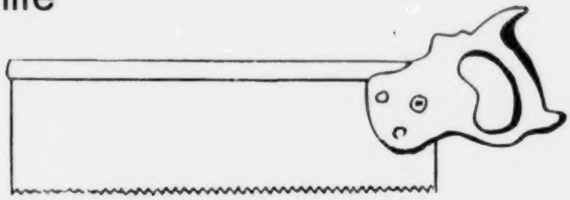
P.V.C Cleaner



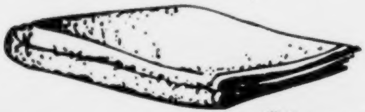
Knife



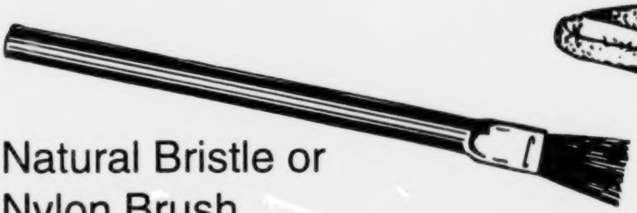
Miter Box



Miter Saw



Clean Towel



Natural Bristle or
Nylon Brush

Iron, Plastic, and PVC Pipe
Unit 6

Information Sheet

1. **Terms and definitions**

   a. **Dope** — A thick, lead-base paste applied to pipe threads to seal a joint

   b. **Electrolysis** — The chemical reaction caused by an electric current passing through certain metals which act as an electrolyte in the presence of earth cover or dissimilar metals

   c. **FPT** — Female pipe threads

   d. **Galvanize** — To coat iron with zinc in order to prevent rusting

   e. **Gas cock** — A manually operated in-line shut-off valve in a gas line

   f. **Long pipe** — Wrought iron or steel pipe

   g. **MPT** — Male pipe threads

   h. **Nipple** — Any piece of pipe 12 inches or less in length

   i. **Nonpotable** — Not suitable for drinking

   j. **NPT** — National pipe taper thread, a standard for deep-V pipe threads prepared to taper 1/16" in diameter for every inch of thread length

   k. **PB** — Polybutylene, flexible plastic pipe and tubing used in low-pressure applications with nonpotable water lines

   l. **PE** — Polyethylene, flexible plastic pipe and tubing used in ground-coupled heat pump applications and for gas lines

   m. **Teflon tape** — A tape applied to pipe threads to help seal a joint and fight corrosion

2. **Black iron pipe in HVAC applications**

   a. Black iron pipe is traditionally used for piping natural gas or LPG gas to furnaces.

   b. Black iron pipe is used for some compressed air lines.

Information Sheet

c. Black iron pipe is used for both chilled liquid lines and for steam lines as well as other hydronic heat applications.

d. Black iron pipe is painted black to help it fight rust and corrosion, to make it easy to distinguish from galvanized iron pipe, and wrought iron and steel pipe, often called long pipe.

3. Galvanized pipe in HVAC applications

a. Galvanized pipe is coated with zinc to help it resist rusting, and is used on all kinds of water-carrying lines such as chilled water lines and ice-maker water lines.

b. Galvanized pipe is also used on water-cooled condenser supply and return lines and on condensate lines.

c. Galvanized pipe should not be used for any kind of gas line.

4. Polybutylene and polyethylene in HVAC applications

a. Flexible plastic tubing and pipes made of PB (polybutylene) and PE (polyethylene) are being used more and more in a variety of HVAC applications.

Note: Flexible plastic pipe usually has a higher density than flexible tubing, but for the most part the two types of flexible plastic are generally identified by available forms; tubing is available in coils of various sizes, and pipe is available in straight runs.

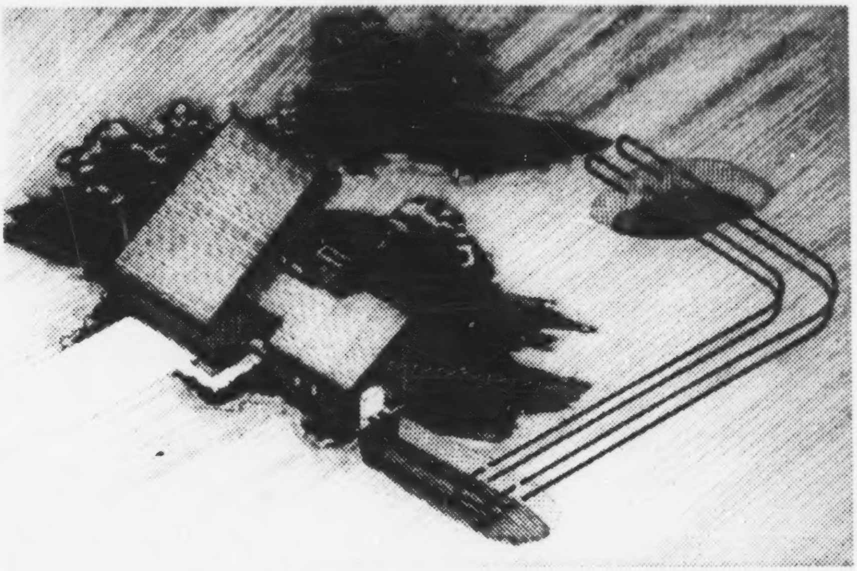
b. PB and PE have long been used for plumbing lines in manufactured homes, but their applications extend over a wide range of HVAC services such as hydronic radiant floor heating, fire sprinkler systems, irrigation systems, and earth-coupled heat pump loops.

c. PB and PE resist most chemicals, they are both resistant to electrolysis and corrosion, and they even resist ultra violet degradation; the expected service life of both PB and PE is set at 50 years plus.

d. PB tubing is highly flexible, lightweight, and easy to clamp into place, so it is used for applications such as condensate lines and nonpotable water service; PB and PE pipe can be joined with heat fusion processes that make service-free connections.

Information Sheet

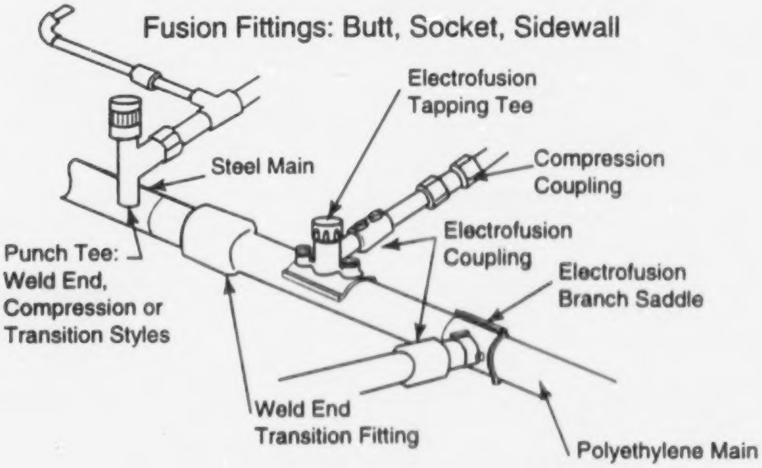
e. PB and PE are both used in ground-coupled heat pump applications, and because they are available in large rolls of up to 500 feet, they can be installed in connection-free long runs that minimize service needs.



HORIZONTAL HEAT EXCHANGER

Courtesy Water Furnace International

f. Higher density polyethylene is used for gas transport lines because it resists corrosion and most chemicals and has other service characteristics that make it a more practical application than metal tubing or pipe.


Fusion Fittings: Butt, Socket, Sidewall
Electrofusion Tapping Tee
Compression Coupling
Steel Main
Electrofusion Coupling
Electrofusion Branch Saddle
Punch Tee: Weld End, Compression or Transition Styles
Weld End Transition Fitting
Polyethylene Main

Courtesy Central Plastics, Shawnee, Oklahoma

g. Yellow is the international color used to indicate pipe or tubing used for gas lines, but American-made polyethylene may be black, tan, orange, or other colors; the international yellow color is being phased into American production.

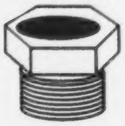
5. **Guidelines for using iron pipe fittings**

   a. Use black iron pipe fittings on black iron and galvanized pipe fittings on galvanized iron.

   b. Use pipe dope or Teflon tape to assure fittings make up properly and are protected against corrosion.

   c. Use an insulated union when joining galvanized pipe to any other kind of pipe; this union has dielectric characteristics that help prevent corrosion when pipes of unlike materials are joined.

   d. Use other iron pipe fittings for general service applications such as change-direction connections, extensions, and reductions.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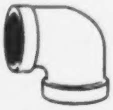
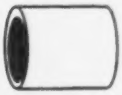
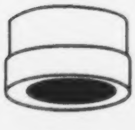

90° Ell


Coupling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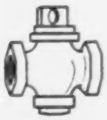
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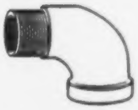
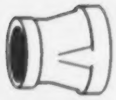
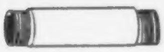
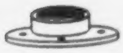
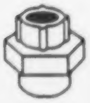

90° Street Ell


Reducer


Nipple


Flange

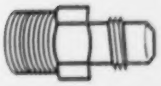

Union

Information Sheet

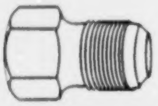
6. Guidelines for using brass fittings

a. Use brass fittings only for copper pipe.

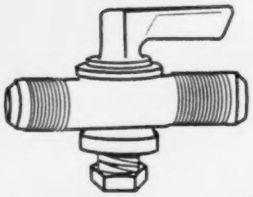
b. Make up brass fittings with dope or Teflon tape, except for connections that have bevels for use with flare nuts.



Male pipe-to-flare

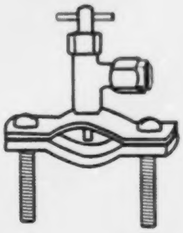


Female pipe-to-flare



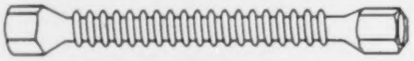
Two-way shut-off valve

c. Use pure copper saddle valves for takeoffs from copper water supply lines; these are common sources for water to refrigerator ice makers.



d. Use flexible gas connectors from a gas supply line to a gas valve only when you know they are permitted by local codes.

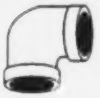
e. Make sure flexible gas connectors have dielectric characteristics; if a connector is not tagged with a "dielectric" notification, do not use it.



Flexible gas connector

Information Sheet

f. Use other brass fittings for general service applications such as change-direction connections, extensions, and reductions.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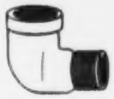
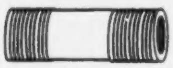
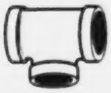
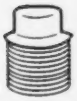
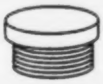
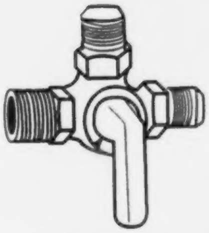

Street Ell


Nipple


Tee


Plug

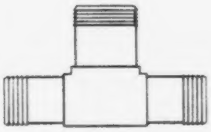

Bushing

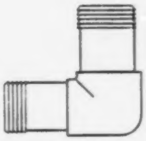

Three-Way
Shut-Off Valve

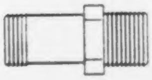
7. **Guidelines for using flexible plastic fittings**

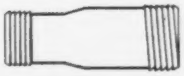
   a. Use plastic fittings only for connections on hose or other than PE or PB.

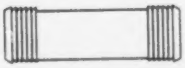
   b. Insert a fitting into pipe or tubing and seal the connection with a clamp.

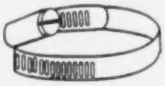

Insert Tee


Insert 90° Ell


Insert-to-MPT Adapter


Insert-to-MPT
Steel Adapter


Insert Connector


Clamp

8. **Guidelines for using PVC fittings**

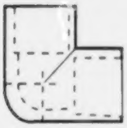
   a. Use PVC fittings only on PVC or CPVC pipe, not on ABS plastic pipe.

   b. When making up unthreaded joints, use primer before applying solvent cement on PVC and CPVC pipe, but use solvent cement only on ABS plastic pipe.

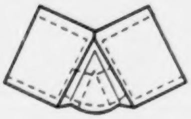
Information Sheet

c. When making up threaded PVC joints, use Teflon tape, but do not use pipe dope.

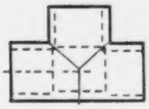
d. Confine pressure testing to low-pressure air supplies, but do not use compressed air to check a PVC line or fitting.



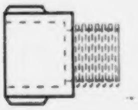
90° Ell



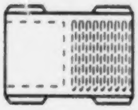
45° Ell



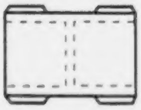
Tee



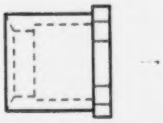
Male Adapter



Female Adapter



Coupling



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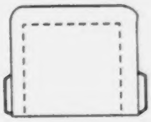
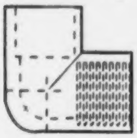


Cap



90° Ell
P.V.C. to Pipe

9. Guidelines for working with polybutylene and polyethylene

a. Both PB and PE can be joined mechanically with clamps or can be fused together with a heat/fusion process using an electric heater, a torch, or a special computer.

b. Because PB is more rubbery and flexible than PE, PB tubing is used for a lot of nonpotable water line, drains, or condensate lines where tubing can be mechanically clamped onto couplings or other fittings.

c. Butt fusion is used on both PB and PE; it is a process where tubing ends are butted against each other and fused together to create a long run of connection-free tubing, a desired condition for earth-coupled heat pump loops.

d. Socket fusion requires special hand tools for placing fittings onto tubing for making turns or creating service access; socket fusion is used on heat pump loops and especially on gas line applications where service tees and other fittings are common.

e. Sidewall fusion also requires tools for tapping into a line and making a tee; this application permits a service entrance to be placed onto a gas main so the entrance to a residence can be tapped into at a later date as needed.

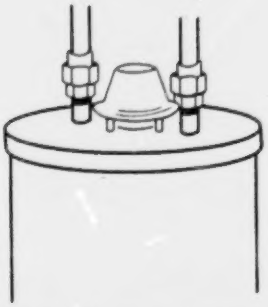
Note: Sidewall fusion is sometimes called "saddle fusion" because the base of the tee fits over the gas main like a saddle.

f. Electronic fusion uses a portable computer, special fittings, and other special equipment to fuse tubing and to evaluate the quality of the connection, all in one procedure; computer verification of joint quality is to assure a service-free connection.

g. All of the fusion processes used with PB and PE require a technician be trained and certified in the processes.

10. Guidelines for using PE dielectric unions in HVAC applications

a. Dielectric unions are required to isolate hot water heater tanks from copper tubing; the manufacturer's warranty is invalid if the proper union is not installed.

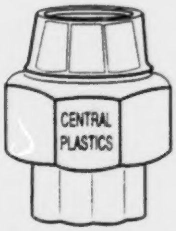


Courtesy Central Plastics, Shawnee, Oklahoma

b. Dielectric protection is required because of the problem that arises when two dissimilar metals are joined together in the presence of water; the condition creates an electric current that promotes electrolysis and galvanic corrosion; in fact, the presence of heat speeds the corrosive process.

c. Dielectric unions also stop the flow of stray electrical currents which may be picked up from nearby electrical lines or appliance grounding connections.

d. Dielectric unions made of nylon insulated malleable iron are ideal protection devices because they not only provide the dielectric protection, but resists galvanic corrosion and will not loosen from strain or vibration.



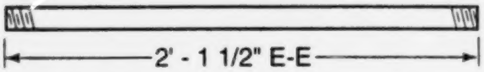
Courtesy Central Plastics, Shawnee, Oklahoma

Information Sheet

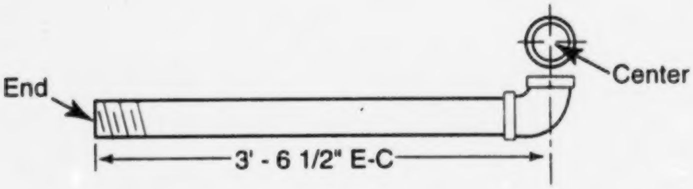
e. Dielectric unions have several air conditioning applications, and also for related service areas such as water pumps, water conditioners, steam lines, fan coil units, finned tube radiation and convectors, and for gas meter piping and other gas heating applications.

11. Guidelines for measuring pipe

a. Measuring a straight run of pipe with no allowance for fittings is called an end-to-end measurement.

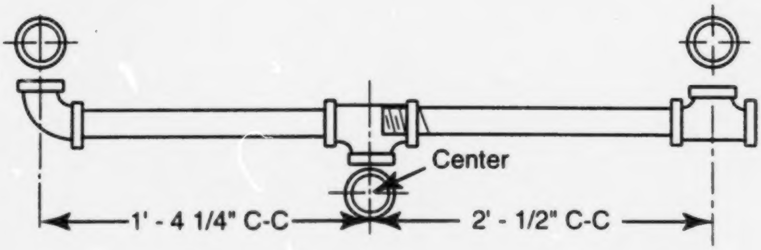


b. Measuring from the end of a pipe to the center of a fitting is called an end-to-center measurement.



c. Measuring from the center of one fitting to the center of the next fitting is called a center-to-center measurement.

d. Measuring from end-to-center or center-to-center makes allowance for thread engagement, the length that a threaded pipe will extend into a fitting.

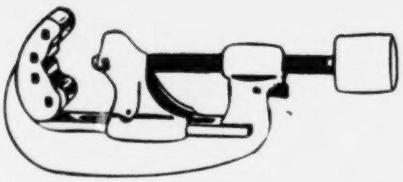


e. Always allow for thread engagement when measuring and making up pipe on the job.

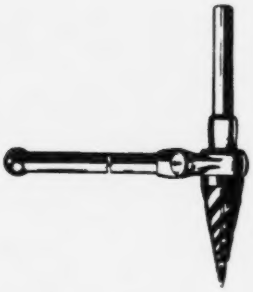
Information Sheet

12. Tools for cutting and threading iron pipe

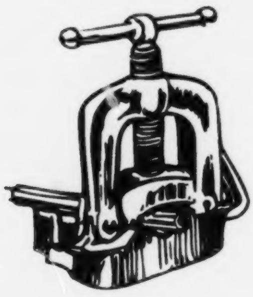
a. When a single pipe or only a few pieces of pipe have to be cut, a hand-held pipe cutter is a favorite tool because it is relatively inexpensive, highly portable, and easy to use.



b. Just like copper tubing, once a pipe has been cut, the end has to be reamed and this can be done with a hand-operated reamer.

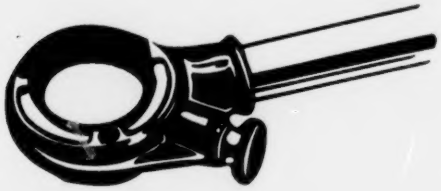


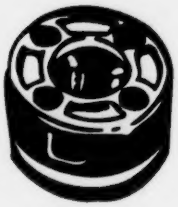
c. Any pipe vise has special clamping jaws for holding pipe and is a must for assuring straight threading.



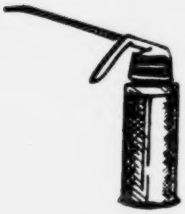
Information Sheet

d. The special die used for threading pipe gives the pipe tapered threads, and the die stock secures the die and makes the threading an easy job.





e. An oil can is a must for cutting and threading pipe because the threads must be oiled with a special sulphur-based cutting oil at almost every turn to control heat and avoid damage to the die and pipe; a catch pan for catching oil is also a required pipe cutting/threading tool.



13. The pipe threading chart

a. To thread a pipe properly, verify the nominal size of the pipe you're going to be threading.

b. Since the approximate length of the threads in inches and the number of threads you should cut are related to nominal pipe size, the best procedure is to use a pipe threading chart.

Information Sheet

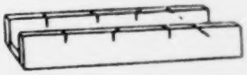
c. A pipe threading chart may list the number of threads per inch, but it is easier to relate the diameter to the approximate number of threads that should be cut, and the approximate length of those threads; this permits a quick check with a tape measure to verify proper threading.

Pipe Threading Chart

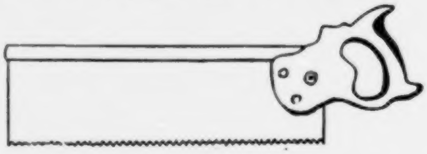
Nominal Size of Pipe in Inches	Approx. Length of Thread in Inches	Approx. Number of Threads To Be Cut
½	¾	10
¾	¾	10
1	⅞	10
1¼	1	11
1½	1	11
2	1	11
2½	1½	12
3	1½	12
4	1⅔	13

14. Tools for working with PVC

a. Straight 90° cuts on PVC can be made with a miter box and a saw, but a PVC cutter takes less time and usually provides a cleaner cut.

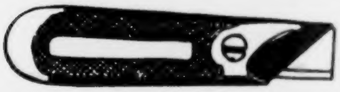


Miter box and saw



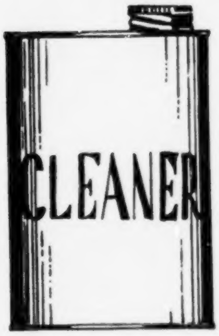
PVC cutter

b. A knife is required for cutting and trimming, and a knife with a retractable blade is probably safer to handle and transport.

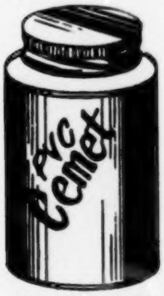


Information Sheet

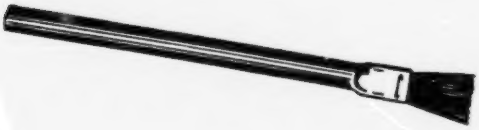
c. PVC cleaner is required to prepare the pipe for joining, and a clean, cotton shop cloth is needed for cleanup.



d. PVC cement is required for joining the pipe to fittings or for joining fittings to fittings.



e. Applying PVC cement requires a small brush with a natural bristle or a nylon brush, and many PVC cement manufacturers include the brush on the underside of the cap that seals the cement can.



Iron, Plastic, and PVC Pipe
Unit 6

Job Sheet 1—Cut and Ream PVC Pipe and Join it to a Fitting

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
PVC pipe properly cut and reamed	______
PVC pipe and fitting cleaned and checked for fit	______
Primer and solvent safely and properly applied	______

A. Tools and materials

PVC pipe and fitting as selected by instructor
PVC pipe-cutting tool or saw and miter box
Deburring tool or knife
NIBCO/Chemtrol purple primer or equivalent
NIBCO/Chemtrol PVC solvent cement
Can or bucket to hold primer and solvent
Clean cotton rag (do not use a synthetic cloth rag)
Two ½″ pain brushes with natural fibers
Gloves and safety glasses

B. Procedure

☐ 1. Put on gloves and safety glasses and cut the pipe with the saw or pipe cutter.

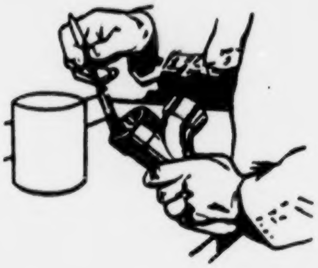
☐ 2. Remove the burrs from the outside and inside of the pipe with a reamer or a knife.

☐ 3. Wipe the pipe and the fitting clean with a clean, cotton rag.

☐ 4. Check the dry fit of the pipe and fitting; the pipe should go into the fitting about ¾ of the way.

Job Sheet 1

☐ 5. Apply primer to the socket of the fitting with the natural-fiber brush, but do not overapply so that the primer puddles in the socket.



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☐ 6. Apply primer to the pipe surface equal to the depth of the fitting.

☐ 7. Apply primer again to the socket of the fitting; primer softens the plastic surfaces of the pipe and fitting to make them responsive to solvent cementing.

☐ 8. Use a clean applicator to apply a full, even coat of solvent cement to the pipe, equal to the depth of the fitting socket.

☐ 9. Coat the socket with a medium layer of solvent cement, but do not permit the cement to puddle in the socket.

☐ 10. Apply a second full, even layer of cement to the pipe.

☐ 11. Place the fitting and pipe together while the cement is still wet, and use sufficient force to make sure the pipe bottoms in the socket of the fitting.

☐ 12. If you can, twist the pipe or fitting about ⅛ to ¼ turn as you make the assembly.

☐ 13. Hold the joint together for about 30 seconds to make sure it does not separate.

☐ 14. Wipe off excess cement with a rag, but do not disturb the joint.

☐ 15. Permit the joint to dry for about 3 minutes.

☐ 16. Have your instructor check your work.

Job Sheet 1

☐ 17. Clean up area and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Iron, Plastic, and PVC Pipe
Unit 6

Job Sheet 2—Cut, Ream, and Thread Iron Pipe

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Pipe properly secured and cut straight	______
Die and die stock properly placed and used	______
Threads clean and straight	______

A. Tools and materials

Iron pipe as selected by instructor
Pipe vise and or power pipe tripod and threader
Deburring tool
Pipe die and die stock
Oil can with cutting oil
Catch pan
Cleaning brush and cleaning rags
Retractable tape or rule
Gloves and safety glasses

B. Procedure

☐ 1. Put on gloves and safety glasses.

☐ 2. Secure the pipe in the power pipe threader or pipe vise.

☐ 3. Measure the I.D. of the pipe.

☐ 4. Check the following pipe threading chart to determine the length of threads in inches and the approximate number of threads required.

Job Sheet 2

Pipe Threading Chart

Nominal Size of Pipe in Inches	Approx. Length of Thread in Inches	Approx. Number of Threads To Be Cut
½	¾	10
¾	¾	10
1	⅞	10
1¼	1	11
1½	1	11
2	1	11
2½	1½	12
3	1½	12
4	1⅔	13

☐ 5. Place the catch pan below the end of the pipe where you will be cutting so shavings and oil will drop into it.

☐ 6. Install the cutter on the pipe, tighten it snugly but not too tight, and move it around the pipe and retighten as needed until the pipe is cut.

☐ 7. Check cut end of pipe to make sure it is square.

☐ 8. Ream inside the pipe to remove burrs.

☐ 9. Check the cutting die before you put it on the pipe; it should be clean and the cutting edges should be sharp.

☐ 10. Center the die on the pipe and make sure the die is properly engaged in the die stock.

☐ 11. Apply two or three drops of cutting oil to the die threads.

☐ 12. Turn the die slowly clockwise and apply cutting oil as needed to keep the threads cool and make cutting easier.

☐ 13. Stop and remove shaving and chips if you encounter resistance.

☐ 14. Cut the number of threads previously determined from the specifications chart.

☐ 15. Remove chips from around the threads.

☐ 16. Turn the die counterclockwise to remove it.

Job Sheet 2

☐ 17. Clean chips from the threads and from the die.

☐ 18. Have your instructor check your work.

☐ 19. Clean up area and return tools and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Iron, Plastic, and PVC Pipe
Unit 6

Job Sheet 3—Join Flexible Plastic Pipe With a Butt Fusion Process

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Flexible plastic pipe properly prepared	______
Butt fusion machine at proper temperature	______
Connection well formed and serviceable	______

A. Tools and materials

Butt fusion machine
Clamping device
Trimming device
Heating tool
Butt fusion heating faces
Watch with second hand or stop watch
Safety glasses

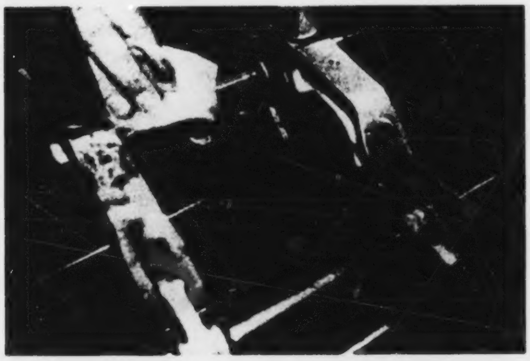
B. Procedure

☐ 1. Take time to read through this job sheet because parts of it have to be accomplished with split-second timing, and the last page of this activity includes timing charts that you should examine before you continue.

☐ 2. Put on safety glasses.

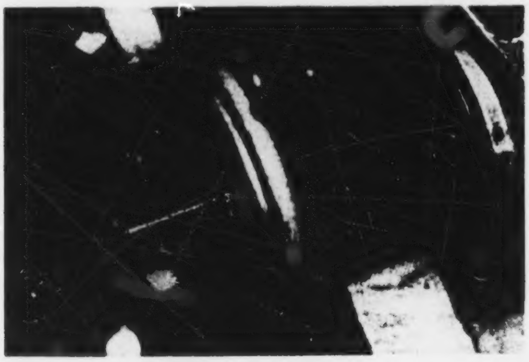
Job Sheet 3

☐ 3. Align pipes or pieces of tubing in the clamping device, and clean the pipe ends with a clean cotton cloth.



☐ 4. Trim the pipe ends by placing the trimmer between the pipe ends and moving the ends against the cutter blades so that a thin, continuous strip of material is trimmed from both ends.

Note: It will take practice to avoid having shavings stick to the ends, so don't be disappointed if you don't get it the first or second time.



☐ 5. Remove shavings from the cut ends, being careful not to touch the newly faced ends and contaminating the ends with perspiration or dirt.

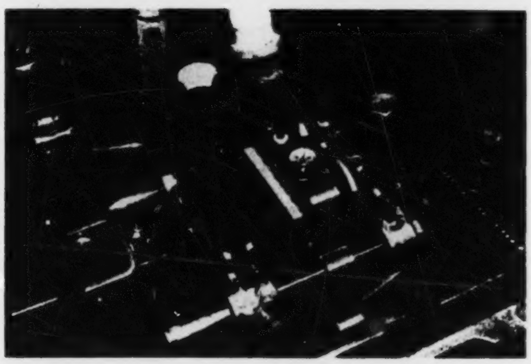
☐ 6. Check alignment of the ends by bringing the ends together and carefully running your finger around the two ends to make sure the ends fit with a gap no larger than .010".

Note: You may need to tighten one of the clamps to bring the ends into alignment; using your finger on the outside of the pipe will not pose a danger to the joining face of the pipe.

Job Sheet 3

☐ 7. Place the Time Cycle Charts that accompany this job sheet out beside the work area so you can refer to them as needed, and then preheat the heating tool to 500°F.

☐ 8. Place the heating tool between the ends of the tubing and apply firm, steady pressure so that the ends are forced against the heating tool.



☐ 9. Observe the melt bead as it develops, and maintain steady pressure until a small bead of molten material is visible around the entire circumference of both ends.

☐ 10. Relax the firm pressure to slight finger pressure just enough to maintain contact of the pipe ends to the heating tool.

☐ 11. Heat the ends for approximately half a minute or as indicated on the timing cycle chart for the type of pipe you are using.

☐ 12. Visually confirm that a proper bead has been obtained on both pipe ends.

Note: The following steps need to be accomplished quickly, so plan ahead.

☐ 13. Snap one pipe end away from the heating tool, and then bump the heating tool slightly to snap it away from the other pipe ends.

☐ 14. Remove the heating tool quickly but be careful not to remove any molten material from the fusion area.

☐ 15. Quickly inspect the pipe ends for an even melt pattern.

☐ 16. Immediately bring the ends together with enough force to obtain a roll back of each bead onto each pipe end.

☐ 17. Maintain the joining pressure for at least one minute.

Job Sheet 3

☐ 18. Allow the joint to cool for a minute and a half before removing it from the clamps.

☐ 19. Inspect the entire circumference of the fusion joint for uniform roll back of the bead on both ends of the pipe.

☐ 20. Allow an additional three minutes of cooling time before installing the pipe.

☐ 21. Have your instructor check your work.

Note: Your instructor may request that you cut a sample from the joint area for testing. In that case, allow an extra 10 minutes of cooling time before cutting on the cutting through the joint area lengthwise. Then, examine the cut surface of the tubing wall for voids or unbonded areas. Certification for butt fusion work requires a test of this nature.

☐ 22. Clean up area and return equipment and materials to proper storage.

Evaluator's comments: ____

____

____

Job Sheet 3

Butt Fusion Time Cycles for PE 2406 Fittings

Pipe Size (IPS)	Heating Time (Sec.)		Cooling Time (Sec.)
	440°F ± 10°F	500°F ± 10°F	
	226°C ± 5°C	260°C ± 5°C	
¾″	15	7	50
1″	20	10	50
1¼″	25	12	50
1½″	40	15	60
2″	40	15	60
3″	50	20	80
4″	55	20	80
6″	90	40	150
8″	**	**	**

Guideline only, exact time could vary depending on environmental conditions and condition or fusion equipment used.

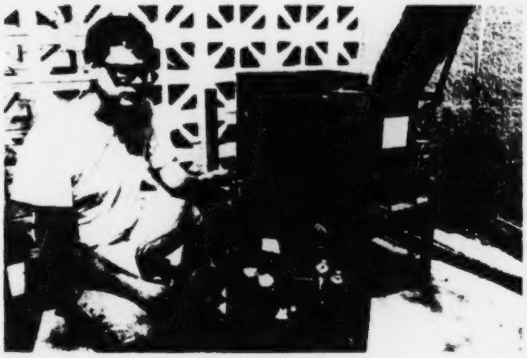
Courtesy Central Plastics, Shawnee, Oklahoma

Butt Fusion Time Cycles for PE 3408 Fittings

Pipe Size (IPS)	Heating Time (Sec.) 500°F ± 10°F	Cooling Time (Sec.)
	260°C ± 5°C	
¾″	12	50
1″	15	50
1¼″	18	70
1½″	22	70
2″	25	70
3″	30	70
4″	35	90
6″	55	160
8″	**	**

Guideline only, exact time could vary depending on environmental conditions and condition or fusion equipment used.

Courtesy Central Plastics, Shawnee, Oklahoma



Soldering, Welding, and Brazing Equipment
Unit 7

Objective Sheet

Unit Objective

After completing this unit, the student should be able to safely light, adjust, and shut down an air-acetylene torch, safely light, adjust, and shut down an air-acetylene torch with a swirl tip, and safely light, adjust, and shut down an oxyacetylene torch. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms relating to soldering and welding equipment with their correct definitions.
2. Complete a chart about soldering, brazing, and welding parameters.
3. Select true statements about characteristics and components of an air-acetylene torch.
4. Select true statements about modern torch tip design for soldering and brazing.
5. Solve problems about self-lighting torch designs for soldering and brazing.
6. Differentiate between types of acetylene tanks and their applications.
7. Complete statements about guidelines for lighting, adjusting, and shutting down an air-acetylene torch.
8. Complete a list of equipment needed for oxyacetylene welding and brazing.
9. Complete statements about pressure regulating valves and adjusting screws.
10. Match oxyacetylene hoses with their characteristics.
11. Identify parts of a welding/brazing torch.

Objective Sheet

12. Complete statements about oxyacetylene welding/brazing tips and their uses.
13. Select true statements about filler materials for oxyacetylene welding/brazing.
14. Match tip cleaning tools with their uses.
15. Select true statements about guidelines for cleaning tips.
16. Complete statements about eye protection required for oxyacetylene welding/brazing.
17. Complete a list of steps for setting up oxyacetylene equipment.
18. Complete a list of steps for lighting, adjusting, and shutting down an oxyacetylene torch.
19. Solve problems about safety guidelines for flashback and backfire.
20. Select true statements about safety rules for oxyacetylene cylinders and gases.
21. Light, adjust, and shut down an air-acetylene torch. (Job Sheet 1)
22. Light, adjust, and shut down an air-acetylene torch with a swirl tip. (Job Sheet 2)
23. Light, adjust, and shut down an oxyacetylene welding/brazing torch. (Job Sheet 3)

Soldering, Welding, and Brazing Equipment
Unit 7

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Develop teaching plan. Adjust for different learning styles.

5. Make copies of the Unit Evaluation Form.

Delivery and Application

6. Provide students with unit of instruction.

7. Discuss unit and specific objectives.

8. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

9. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Evaluation

10. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

11. Make copies of the written test. Add or modify test items as needed.

12. Give written test.

13. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

14. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Emphasize the air-acetylene torch as you teach this unit, but arrange for students to spend some time in the welding class to learn basic skills in oxyacetylene cutting and brazing. Oxyacetylene skills are not a "must" for ACR technicians, but jobs where an angle iron brace has to be cut in order to perform other ACR service can be done much faster and much cheaper if the ACR technician can hook up an oxyacetylene torch and do the cutting. Materials for working with a cutting torch are included in Teacher Supplement 1 which can be reproduced for students if you want to add it to student activities. If you do, plan an appropriate evaluation. Skill areas: **Learning skills, learning to learn.**

2. Invite a technician from a local ACR company to talk to students about the general area of soldering and brazing. Have the guest speaker emphasize the type of equipment that is most effective for the most number of jobs. Skill areas: **Foundation Skills, listening.**

3. Objectives 4 and 5 can be enriched if you'll have a local or area distributor demonstrate to the class the variety of new designs in torches and how they contribute to improved soldering and brazing. It would really be effective if you can get someone from Victor Equipment or Prest-O-Lite® to talk to the class about swirl technology and demonstrate how the "flame without a feather" has revolutionized soldering and brazing. Skill areas: **Foundation skills, listening.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1994.

3. *Oxyacetylene Welding and Cutting,* 2nd ed. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1992.

Suggested Activities

Suggested Supplemental Resources

The Welding Handbook, Vol. 1, 8th ed., and *The Welding Handbook, Vol. 2*, 8th ed. are both available from the American Welding Society in Miami, Florida. The two texts are dedicated to welding, but contain significant materials about both soldering and brazing. For information, contact:

The American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

You can call AWS at 1-800-443-9353 or FAX them at 1-305-443-7559.

For information about **Surefire™** self-igniting torches, call toll free 1-800-654-9011 or write:

Surefire
One Bernzomatic Drive
Medina, NY 14103

For information about **Turbolite®** self-igniting torches, call toll free 1-800-426-1888 or write:

Turbotorch
Customer Service
P.O. Box 1007
Denton, TX 76202-1007

For information about **Quickfire™** self-igniting torches, call toll free 1-800-328-3363 or write:

Smith Equipment
2601 Lockheed Ave.
Watertown, SD 57201

For information about **Phoenix Torches**, call toll free 1-800-341-5300 or write:

Phoenix Torches
Box 337
Bridgeport, PA 19406

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Suggested Activities

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Soldering, Welding, and Brazing Equipment
Unit 7

Answers to Written Test

1. a. 4
   b. 7
   c. 1
   d. 5
   e. 3
   f. 2
   g. 6

2. a. 840°F and down
   b. Oxyacetylene
   c. Same or similar to base metal
   d. Strength of joint

3. a, b, c

4. a, b, c, e, f

5. a. (3)
   b. (2)

6. a

7. a. about a quarter of a turn
   b. striker
   c. ¾" to 1½"
   d. let the flame burn itself out

8. a. acetylene
   b. Pressure
   c. hoses
   d. check valves
   e. tips
   f. Welding goggles

9. a. cylinder, working or working, cylinder (either answer is correct)
   b. clockwise, counterclockwise

10. a. 3
    b. 2
    c. 4
    d. 1

11. a. 1
    b. 2
    c. 4
    d. 8
    e. 7
    f. 6
    g. 5
    h. 3

Answers to Written Test

12. a. fuel gas
    b. metal thickness
    c. cleaner

13. b, c

14. a. 3
    b. 1
    c. 2

15. b, c

16. a. safety glasses
    b. radiation burns
    c. dark, down

17. a. chained
    b. threads
    c. momentarily
    d. cylinder
    e. cylinder
    f. counterclockwise
    g. check
    h. open end
    i. clockwise
    j. open end
    k. finger
    l. close
    m. adjusting
    n. Leak

18. a. closed
    b. slowly
    c. 15
    d. counterclockwise
    e. pressure
    f. dominant
    g. Purge
    h. slowly
    i. a quarter
    j. sparklighter
    k. blue
    l. slowly
    m. neutral
    n. quickly
    o. cylinders

Answers to Written Test

p. bleed
q. spring
r. Repeat
s. Secure

19. a. (1)
b. (2)

20. a, b, f, g, i, j

Soldering, Welding, and Brazing Equipment
Unit 7

Written Test

Name ______________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions.

______a. A torch that combines acetylene from a cylinder and oxygen in the surrounding air to produce and maintain a flame

______b. A condition caused when flame backs into a welding tip; usually accompanied by a loud pop

______c. A condition caused when a flame continues to burn into the tip, mixer, or torch body; usually accompanied by a loud hiss or squeal

______d. A torch that combines acetylene from a cylinder with oxygen from a cylinder to produce and maintain a flame

______e. Device for reducing high cylinder pressure to a lower, safe working pressure

______f. Joining two base metals together with a process of heating the base metals and a filler material to temperatures above 850°F, but below the melting temperatures of the base metals

______g. Joining two base metals together with a process of heating the base metals and a filler material to temperatures below 840°F and below the melting temperatures of the base metals

1. Flashback
2. Silver brazing
3. Regulator
4. Air-acetylene torch
5. Oxyacetylene torch
6. Soldering
7. Backfire

Written Test

2. Complete a soldering, brazing, and welding parameters chart. Write in the required information in the blanks provided in the following chart.

Factor	Soldering	Brazing	Welding
Temperature	a. __________	840°F and up	1500°F and up
Torch (May be used) *Recommended	(Any) *Air-acetylene	(Any) *Air-acetylene w/swirl tip *Oxyacetylene	b. __________
Filler Material	Not the same as base metal	c. __________	Same as base metal (Sometimes similar)
d. __________	Less than original metal	Equal to original metal	Equal to or stronger than original metal

3. Select true statements about the characteristics and components of an air-acetylene torch. Place an "X" beside each true statement.

______a. The air-acetylene torch is the most popular in AC service because acetylene produces a hotter flame than propane or the other LP gases available for ACR service, and the lightweight rigs are easy to move around.

______b. Components of an air-acetylene rig include a torch handle, a regulator, and a hose, used with an acetylene bottle and a tip selected for the soldering or brazing job at hand.

______c. A standard tip assortment ranges from a No. 1 that produces a very fine flame to a No. 6 which produces an extra large flame; tip selection also includes several advanced designs using "swirl" technology.

4. Select true statements about modern torch tip design for soldering and brazing. Place an "X" beside each true statement.

______a. Traditional torch flames have a feather that wastes much heat, but the new "swirl" technology torch tips like TurboTorch® generate a flame that delivers more effective heat to the target.

______b. The stable, flow-out resistant flame produced by the TurboTorch® tip not only provides maximum heat transfer, it delivers fuel economy and reduces the time a technician has to spend on solder/brazing joint repair.

______c. The terminating helical rotor in the TurboTorch® "swirl" technology produces a wraparound flame that is easier to control because it has no feather and even performs well in rain or wind.

Written Test

______d. TurboTorch® tips are available for air-acetylene only and should be selected as the technician learns from experience how they perform.

______e. The Swirl-Jet® tip from Prest-O-Lite® also employs "swirl" technology to produce a tip with a hotter, shorter flame that concentrates heat in a short wraparound flame.

______f. The Swirl-Jet® is ideal for close up soldering/brazing and works well in sub-zero temperatures, wind, and rain.

______g. Swirl-Jet® tips are available for LP fuel gases only.

5. Solve problems about self-lighting torch designs for soldering and brazing. Circle the number of the statements that provides the best answer to each of the following problems.

   a. You've been assigned a soldering job on a piece of ⅛" tubing on the back side of a unit that is hard to reach. To do the job the fastest, you should probably:

      (1) Make sure you have a long hose for your air-acetylene rig.

      (2) Shut the system down, dismantle the line, and repair the leak in a more convenient spot.

      (3) Use a hand-held self-igniting torch with a small propane cylinder; they're easier to handle and work well on smaller tubing.

   b. You have a soldering job that requires really concentrated heat, but the job is in a place that's hard to get to. To solve the problem, you should:

      (1) Select a large #6 tip for your air-acetylene rig.

      (2) Use a type of self-igniting torch with a tip that can swivel 180°; and use a TurboTorch® tip for good flame characteristics.

      (3) Use a regular air-acetylene rig, but pick a small tip.

6. Differentiate between types of acetylene tanks and their applications. Place an "X" beside the definition of a B tank.

______a. Used on a portable cart so it can be easily moved to a job site; it holds 40 cubic feet of acetylene to provide fuel enough for a large job

______b. Can be hand carried for transport to hard-to-reach places; it contains 10 cubic feet of acetylene to provide fuel enough for smaller jobs

______c. Highly portable cylinders for LP gases such as propane and MAPP®; these cylinders are often used with hand-held, self-igniting torches and are usually a pound or less with some available in larger sizes

Written Test

7. Complete statements about guidelines for lighting, adjusting, and shutting down an air-acetylene torch. Circle the material that best completes each of the following statements.

   a. Use a tank key or a cylinder wrench to open the acetylene tank valve (**about a quarter of a turn**) (**one full turn**).

   b. Open the valve on the torch handle and ignite the air/gas mixture with a (**striker**) (**match or cigarette lighter**).

   c. Adjust to a neutral flame that has an inner blue cone about (**¾" to 1½"**) (**1½" to 2½"**) long.

   d. To extinguish the flame, turn the acetylene tank valve off, (**let the flame burn itself out**) (**gently blow the flame out**), and then close the valve on the torch handle.

8. Complete a list of equipment needed for oxyacetylene welding and brazing. Write in the names of the missing items.

   a. Oxygen and __________________ cylinders

   b. __________________ regulators for oxygen and acetylene tanks

   c. Oxygen and acetylene __________________ encased together

   d. Welding torch with __________________ to prevent flashback

   e. Assorted welding/brazing __________________

   f. __________________ and safety glasses

   g. Sparklighter

   h. Cylinder wrench

   i. Wire brush

9. Complete statements about pressure regulating valves and adjusting screws. Circle the material that best completes each of the following statements.

   a. Each regulator, oxygen and acetylene, has two gauges mounted on a single manifold, and one gauge indicates the (**cylinder**) (**working**) pressure and the other gauge indicates (**working**) (**cylinder**) pressure for the torch.

   b. Each regulator has an adjusting screw so pressure to the torch can be quickly controlled by turning the screw (**clockwise**) (**counterclockwise**) to increase pressure or (**counterclockwise**) (**clockwise**) to decrease or completely shut off the pressure.

Written Test

10. Match oxyacetylene hoses with their characteristics. Place the number beside the characteristic in the blank beside the definition of the characteristic.

______a. Special nonporous hoses are used to transfer the gases from the cylinders to the torch

______b. Acetylene hoses are always red; oxygen hoses are usually green, but sometimes black

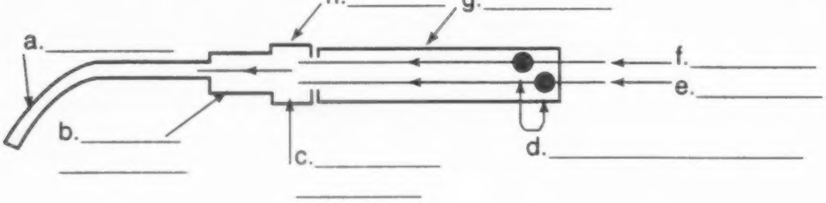
______c. Acetylene connectors have a V-groove and left-hand threads, and oxygen connectors have a plain surface and right-hand threads

______d. New hoses are coated inside with a powder to provide protection in storage and new hoses should definitely be purged by attaching them to proper cylinders and opening the regulators to about 5 pounds of pressure

1. New hoses
2. Color
3. Transport
4. Connector threads

11. Identify parts of a welding/brazing torch. Place the number beside the name of the torch part in the proper blank in the illustration.

1. Tip
2. Mixing throat
3. Head nut
4. Mixer or ejector
5. Body
6. Oxygen hose
7. Acetylene hose
8. Control needle valves



Written Test

12. Complete statements about oxyacetylene welding/brazing tips and their uses. Circle the material that best completes each of the following statements.

    a. Welding/brazing tips should be selected according to the thickness of the metal workpiece and the type of (**filled material**) (**fuel gas**) used.

    b. The tip selected along with (**metal thickness**) (**filler material**) also determines operating oxygen/acetylene pressures that should be used.

    c. Check manufacturer's guidelines or a tip selection chart for drill size; this indicates the size of the tip when it is new, and the tip (**nip**) (**cleaner**) should be selected based on the drill size.

13. Select true statements about filler material selection for oxyacetylene welding and brazing. Place an "X" beside each true statement.

    ______a. For both welding and brazing, filler rods and filler materials should have the very same properties as the base metal.

    ______b. As a general rule, the diameter of the filler rod or material should be equal to the thickness of the metal being welded or brazed.

    ______c. When working with a filler rod, bend the end of the rod over to avoid accidental eye injury, and always wear proper eye protection when welding/brazing with oxyacetylene equipment.

14. Match tip cleaning tools with their uses. Place the number beside the tool in the blank beside the description of its use.

______a. A miniature drill used for cleaning and reconditioning orifices	1. Tip cleaner
	2. Tip nip
______b. A device with a series of small file-like probes that are gauged to match specific orifice sizes; used to remove carbon buildup inside a cutting tip	3. Tip drill
______c. A circular device with small steel cutting blades inset so it can be placed over the end of a tip and used to both clean and restore the face of the tip	

Written Test

15. Select true statements about guidelines for cleaning tips. Place an "X" beside each true statement.

______a. Always select a probe the same size as the orifice you're cleaning; never force a cleaning probe into an orifice.

______b. Be careful with the seating edges on cutting tips because they can be easily damaged.

______c. Clean tips often, and be very careful not to break a probe off inside a tip; they are difficult and time-consuming to remove.

16. Complete statements about eye protection required for oxyacetylene welding/brazing. Circle the material that best completes each of the following statements.

a. Wear safety glasses when cleaning or chipping on a base metal, and wear (**safety glasses**) (**welding goggles**) plus a face shield when grinding joints or bevels.

b. Wear welding goggles to protect your eyes from spatter, and select a lens shade dark enough to protect your eyes from (**radiation burns**) (**any sparks produced**).

c. As a general rule, start off with a lens shade too (**dark**) (**light**) to comfortably see the work zone, then move (**down**) (**up**) to a lighter shade that afford a good view of the work zone without straining your eyes.

17. Complete a list of steps for setting up oxyacetylene equipment. Write the correct information in the blanks provided.

a. Make sure cylinders are ________________ securely to a cart or wall support.

b. Remove the cylinder caps and clean around the valve ________________ as required.

c. Stand to one side and open the oxygen cylinder valve ________________ and then close it; repeat the procedure for the acetylene cylinder.

d. Attach the oxygen regulator to the oxygen cylinder and tighten it in place with a ________________ wrench.

e. Attach the fuel gas regulator to the fuel gas cylinder and tighten it in place with a ________________ wrench.

Written Test

f. Release pressure on both regulators by turning each regulator adjusting screw __________________ until tension on the adjusting screws is completely released.

g. Attach __________________ valves to regulators.

h. Attach hoses to check valves and tighten both with an __________________ __________________ wrench.

i. Purge both hoses by turning each regulator adjusting screw __________________ for about 5 seconds, and then turn counterclockwise to release pressure.

j. Attach hoses to the torch body and tighten them with an __________________ __________________ wrench.

k. Attach a welding/brazing tip to the torch body and tighten __________________ tight.

l. Turn the torch needle valves clockwise to __________________ them.

m. Set 5 to 10 psi on each regulator by turning the individual __________________ screws clockwise until the working gauge pressure reads the desired pressure.

n. __________________ test all threaded connections with leak detector solution that contains no oil.

18. Complete a list of steps for lighting, adjusting, and shutting down an oxyacetylene torch. Write the missing information in the blanks provided.

a. Make sure all torch valves and all cylinder valves are __________________.

b. Open the acetylene cylinder valve __________________ about half a turn.

Written Test

c. Tighten the acetylene regulator adjustment screw until the regulator shows the recommended operating pressure, but never more than __________________ psi for acetylene.

d. Open the oxygen cylinder valve slowly __________________ as far as it will go.

e. Turn the adjustment screw on the oxygen regulator adjustment screw clockwise until the regulator indicates the recommended __________________ for the tip.

f. Take the torch in your __________________ hand and point the tip down and away from you.

g. __________________ the acetylene line by cracking the acetylene needle valve on the torch until you hear acetylene escaping from the torch, and then slowly turn the acetylene needle valve off.

h. Purge the oxygen line by cracking the oxygen needle valve on the torch until you hear oxygen escaping from the torch, and then __________________ turn the oxygen needle valve off.

i. Keep the torch pointed away from you as you open the acetylene needle valve about a __________________ of a turn.

j. Place the __________________ about an inch from the tip of the torch, squeeze it quickly and firmly, and light the torch.

k. Open the acetylene needle valve until a __________________ flame appears and carbon smoke diminishes.

l. Open the oxygen needle valve on the torch __________________ to allow oxygen to mix with the acetylene.

m. Continue opening the oxygen needle valve until the flame shows a sharp inner cone of fire with no acetylene feather; this is a __________________ flame and the best flame to use for brazing.

n. Close the oxygen needle valve on the torch, and then ________________ close the acetylene needle valve on the torch.

o. Close the oxygen and acetylene valves on the ________________.

p. Open the oxygen needle valve on the torch to ________________ the oxygen line, and keep it open until the oxygen regulator returns to zero.

q. Turn the oxygen regulator adjustment screw until ________________ tension is released, and then close the oxygen needle valve on the torch.

r. ________________ the shutdown procedure for the acetylene side of the system.

s. ________________ the equipment.

19. Solve problems about safety guidelines for flashback and backfire. Circle the number beside the statement that best completes each of the following statements.

a. You are setting up an oxyacetylene torch and you hear a loud pop. For safety reasons, you should:

(1) Shut the equipment down and check it if the loud pop is repeated more than once; you are experiencing backfire.

(2) Shut the equipment down immediately; you are experiencing flashback.

b. You are using an oxyacetylene torch on a brazing job and suddenly hear a loud squealing sound. For safety reasons, you should:

(1) Shut the equipment down and check it if the squeal is repeated more than once; you are experiencing backfire.

(2) Shut the equipment down immediately; you are experiencing flashback.

Written Test

20. Select true statements about safety rules for oxyacetylene cylinder and gases. Place an "X" beside each true statement.

_______a. Secure cylinders in a vertical position in a clear area, and blow out the cylinder valves before attaching regulators.

_______b. Release the adjusting screw on each regulator before opening the cylinder valve.

_______c. Stand directly in front of the regulator when opening a cylinder valve so you can see the pressure needle better.

_______d. Open the cylinder valve quickly to properly initiate the regulator.

_______e. Do not set acetylene pressure at more than 30 psi.

_______f. Purge oxygen and fuel gas lines before lighting the torch.

_______g. Open and light acetylene before opening the oxygen valve on the torch.

_______h. Use oil on regulators, torches, fittings, or other equipment that comes in contact with oxygen only when you really need to.

_______i. NEVER use oxygen as a substitute for compressed air.

_______j. Keep heat, flame, and sparks away from all combustibles.

***Permission to duplicate this test is granted.**

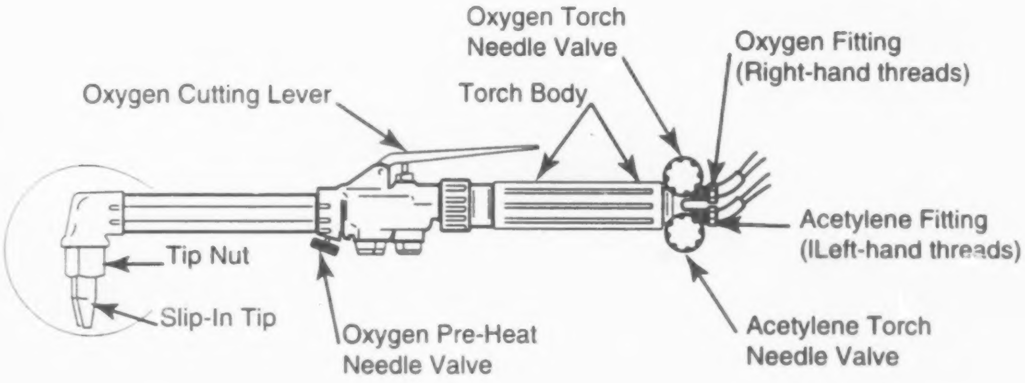
Soldering, Welding, and Brazing Equipment
Unit 7

Teacher Supplement 1—Oxyacetylene Cutting

Students with skills setting up oxyacetylene equipment for brazing should be able to quickly learn how to set up and cut with an oxyacetylene cutting torch. The following materials are presented for optional presentation as placement needs may require.

The oxyacetylene cutting torch

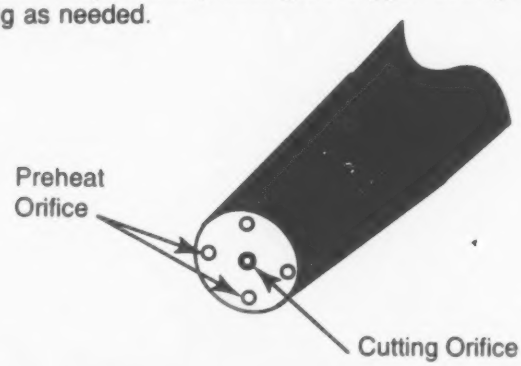
Setting up for cutting operations is the same as setting up for welding/brazing. The cutting torch hooks with the same type hose connections as a welding/brazing torch; the adjusting needle valves are virtually the same. The torch items that are different are the oxygen pre-heat needle valve, the oxygen cutting lever, and the tip nut that can be loosened so a slip-in tip can be put in and tightened into place. The oxygen pre-heat needle valve is used to add more oxygen for pre-heating, and the oxygen cutting lever directs a forceful blast of oxygen onto the metal to blow slag away.


Oxygen Torch Needle Valve
Oxygen Fitting (Right-hand threads)
Oxygen Cutting Lever
Torch Body
Acetylene Fitting (ILeft-hand threads)
Tip Nut
Slip-In Tip
Oxygen Pre-Heat Needle Valve
Acetylene Torch Needle Valve

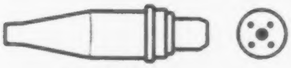
Teacher Supplement 1

Cutting tip design and selection

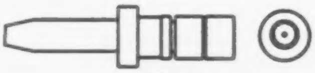
Cutting tips have two or more preheat orifices and a single oxygen orifice which directs a stream of oxygen in response to pressing the oxygen cutting lever, and depending on service, require cleaning as needed.



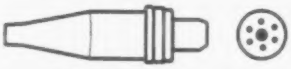
Cutting tips should be selected according to the thickness of the metal being cut with special attention to preheat demands. Tips are also available for fuel gases other than acetylene.


Light Preheat
Light Cutting

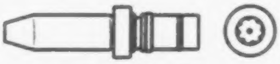
Acetylene


General Purpose

Propane


Medium Preheat
Light Cutting

Acetylene

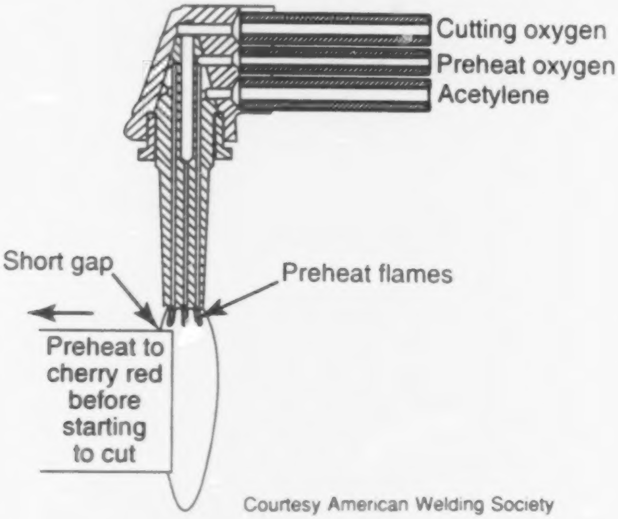

General Purpose

Natural Gas (Methane)

Teacher Supplement 1

Steps for starting a cut

1. Place the cutting tip so that the preheat flame is half on the metal and half off the edge of the metal, and keep the tip perpendicular to the surface of the metal.


Cutting oxygen
Preheat oxygen
Acetylene
Short gap
Preheat flames
Preheat to cherry red before starting to cut

Courtesy American Welding Society

2. Place the cutting tip close to the metal, but do not touch the metal.
3. Preheat the starting point until the metal is cherry red, and then depress the oxygen cutting lever.
4. Tilt the tip slightly in the direction of the cut as cutting starts, and move the tip along the cut line at a constant speed.
5. Vary the torch angle as the thickness of the metal demands; let the action along the cutting lien be your guide.

Soldering, Welding, and Brazing Equipment
Unit 7

Unit Evaluation Form

Student Name ________________________________ Unit Rating ____________

Job Sheet 1—Light, Adjust, and Shut Down an Air-Acetylene Torch Rating ______

Comments: ____

____

Job Sheet 2—Light, Adjust, and Shut Down an Air-Acetylene Torch With a Swirl Tip Rating ______

Comments: ____

____

Job Sheet 3—Light, Adjust, and Shut Down an Oxyacetylene Welding/Brazing Torch Rating ______

Comments: ____

____

Other ____

____

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ________________________________ Date ____________

Student Signature ________________________________ Date ____________

***Permission to duplicate this form is granted.** 374

Soldering, Welding, and Brazing Equipment
Unit 7

Information Sheet

1. **Terms and definitions**

   a. **Air-acetylene torch** — A torch that combines acetylene from a cylinder and oxygen in the surrounding air to produce and maintain a flame

   b. **Backfire** — A condition caused when flame backs into a welding tip; usually accompanied by a loud pop

   c. **Flashback** — A condition caused when a flame continues to burn into the tip, mixer, or torch body; usually accompanied by a loud hiss or squeal

   d. **Oxyacetylene torch** — A torch that combines acetylene from a cylinder with oxygen from a cylinder to produce and maintain a flame

   e. **Regulator** — Device for reducing high cylinder pressure to a lower, safe working pressure

   f. **Silver brazing** — Joining two base metals together with a process of heating the base metals and a filler material to temperatures above 850°F, but below the melting temperatures of the base metals

      Note: Joining metals at temperatures above 840°F and below 1400°F is sometimes called "hard soldering" or "silver soldering" as a nonstandard reference.

   g. **Soldering** — Joining two base metals together with a process of heating the base metals and a filler material to temperatures below 840°F and below the melting temperatures of the base metals

      Note: Joining metals at temperatures below 840°F is sometimes called "soft soldering."

2. **Soldering, brazing, and welding parameters**

   a. AC and refrigeration systems require both maintenance and repair, and repairs to lines and fittings are especially common because lines and fittings get the most wear-and-tear from the "bad guy" trio of service conditions, high-temperature, pressure, and vibration.

   b. How fittings, lines, and tubing are repaired depends on a variety of inter-related conditions that affect not only the type of repair, but the materials and equipment that will be used for the repair.

c. Soldering, brazing, and welding are the major repair techniques, and each process has a range of operating temperatures, acceptable filler materials, and torch applications all designed to achieve an acceptable strength.

Factor	Soldering	Brazing	Welding
Temperature	840°F and down	840°F and up	1500°F and up
Torch (May be used) *Recommended	(Any) *Air-acetylene	(Any) *Air-acetylene w/swirl tip *Oxyacetylene	*Oxyacetylene
Filler Material	Not the same as base metal	Same or similar to base metal	Same as base metal (Sometimes similar)
Strength of joint	Less than original metal	Equal to original metal	Equal to or stronger than original metal

d. The object of good ACR service is to use the repair procedure that will maintain an acceptable strength at minimal costs; this requires some technicians to have skills not just in soldering and brazing, but also welding/brazing with an oxyacetylene torch.

e. Oxyacetylene cutting is another skill that a good ACR technician should acquire because, with soldering and brazing skills, it gives a technician an added edge in the job market and more chances for advancement on the job.

3. Characteristics and components of an air-acetylene torch

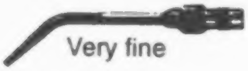
a. The air-acetylene torch is the most popular in AC service because acetylene produces a hotter flame than propane or the other LP gases available for ACR service, and the lightweight rigs are easy to move around.

b. Components of an air-acetylene rig include a torch handle, a regulator, and a hose, used with an acetylene bottle and a tip selected for the soldering or brazing job at hand.

Information Sheet

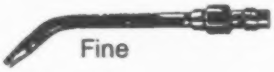
c. A standard tip assortment ranges from a No. 1 that produces a very fine flame to a No. 6 which produces an extra large flame; tip selection also includes several advanced designs using "swirl" technology.

1.



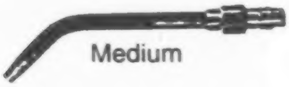
Very fine

2.



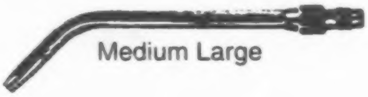
Fine

3.



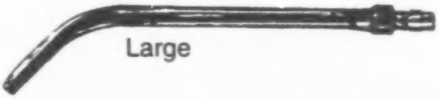
Medium

4.



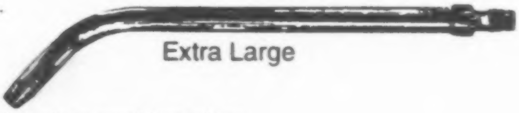
Medium Large

5.



Large

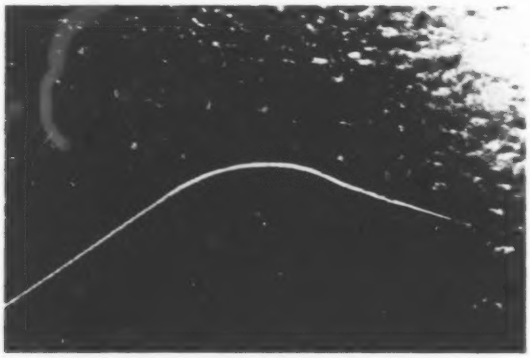
6.



Extra Large

4. Modern torch tip design for soldering and brazing

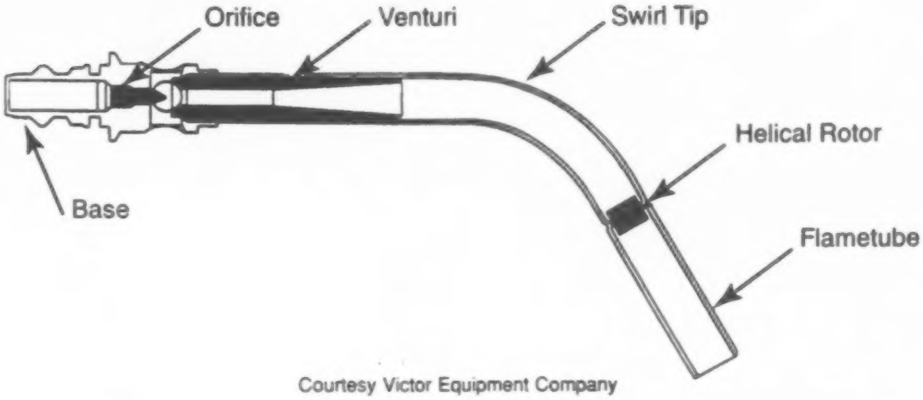
a. Traditional torch flames have a feather that wastes much heat, but the new "swirl" technology torch tips like TurboTorch® generate a flame that delivers more effective heat to the target.



b. The stable, blow-out resistant flame produced by the TurboTorch® tip not only provides maximum heat transfer, it delivers fuel economy and reduces the time a technician has to spend on solder/brazing joint repair.

Information Sheet

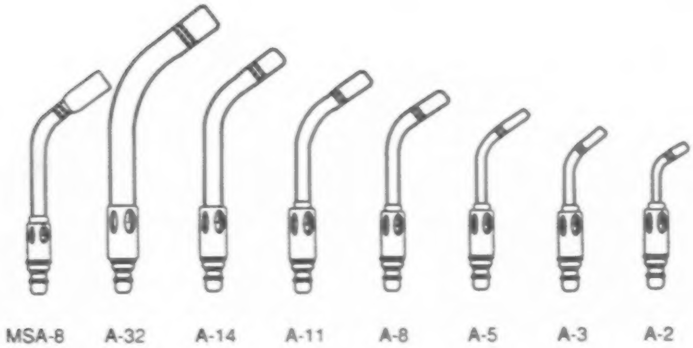
c. The terminating helical rotor in the TurboTorch® "swirl" technology produces a wraparound flame that is easier to control because it has no feather and even performs well in rain or wind.


Orifice
Venturi
Swirl Tip
Helical Rotor
Base
Flametube

Courtesy Victor Equipment Company

d. TurboTorch® tips are available for use with air-acetylene or for LP gases such as propane are MAPP®; tips should be selected by type to match tubing size.

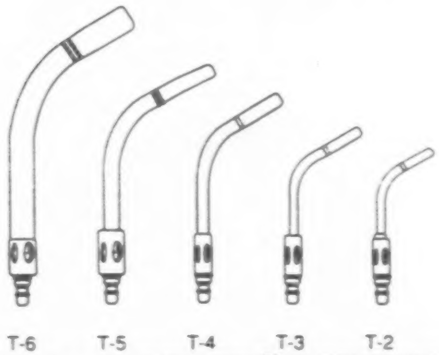
Acetylene Tips


MSA-8
A-32
A-14
A-11
A-8
A-5
A-3
A-2

Information Sheet

	Tip Size		Gas Flow		Copper Tubing Size Capacity				Replacement Orifice Model
			@14 psi	(0.9 Bar)	Soft solder		Silver Solder		
Tip No.	in.	mm	ft.³/hr.	m³/hr.	in.	mm	in.	mm	
A-2	3/16	4.8	2.0	.17	1/8-1/2	3-15	1/8-1/4	3-10	OR-A2
A-3	1/4	6.4	3.6	.31	1/4-1	5-25	1/8-1/2	3-12	OR-A3
A-5	5/16	7.9	5.7	.48	3/4-1 1/2	20-40	1/4-3/4	10-2	OR-A5
A-8	3/8	9.5	8.3	.71	1-2	25-50	1/2-1	15-30	OR-A8
A-11	7/16	11.1	11.0	.94	1 1/2-3	40-75	7/8-1 5/8	20-40	OR-A11
A-14	1/2	12.7	14.5	1.23	2-3 1/2	50-90	1-2	30-50	OR-A14
A-32*	3/4	19.0	33.2	2.82	4-6	100-150	1 1/2-4	40-100	OR-A32
MSA-8	3/8	9.5	5.8	.50	3/4-3	20-40	1/4-3/4	10-20	OR-A5
*Use with Large Tank Only									

Total LP Tips



	Tip Size		Gas Flow		Copper Tubing Size Capacity Propane Gas				Copper Tubing Size Capacity MAPP® Gas				Replacement Orifice Model
			@14 psi	(0.9 Bar)	Soft Solder		Silver Solder		Soft Solder		Silver Solder		
Tip No.	in.	mm	ft.³/hr.	m³/hr.	in.	mm	in.	mm	in.	mm	in.	mm	
T-2	5/16	8.0	.14	.17	1/8-1/4	3-10	1/16-1/4	1-6	1/8-1/2	3-12	1/8-1/4	3-10	OR-A2
T-3	7/16	11.1	20	25	1/4-1	6-25	1/8-1/2	3-10	1/4-1 1/2	10-40	1/4-1/2	6-15	OR-T3
T-4	1/2	12.7	39	48	1/4-1 1/2	10-40	1/4-5/8	6-15	1/4-2 1/2	10-60	1/4-1 1/4	6-35	OR-A3
T-5	3/4	19.0	1.10	1.3	1 1/2-2 1/2	25-60	1/2-1 1/8	15-35	1-4	25-100	1/2-2	15-50	OR-A8
T-6	1	25.4	2.10	2.5	1 1/2-4	40-100	3/4-2	20-50	1 1/2-6	25-150	3/4-4	20-100	OR-T6

Courtesy Victor Equipment Company

e. The Swirl-Jet® tip from Prest-O-Lite® also employs "swirl" technology to produce a tip with a hotter, shorter flame that concentrates heat in a short wraparound flame.

f. The Swirl-Jet® is ideal for close up soldering/brazing and works well in sub-zero temperatures, wind, and rain.

g. Swirl-Jet® tips are available for air-acetylene torches and for use with other fuel gases.

Information Sheet

5. Self-lighting torch designs for soldering/brazing

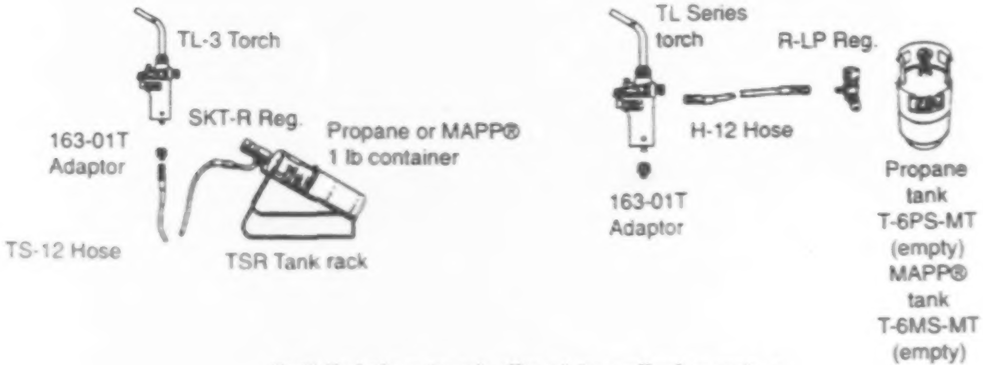
a. Hand-held, self-lighting torches work well on smaller tubing sizes and use "swirl" technology tips that give them power enough to handle a variety of soldering and brazing jobs.

b. The TurboLite® torch is typical of this new breed of torch that lights by pulling the trigger, has a head that swivels 180°, and can be used with propane or MAPP® without having to change the orifice.

Note: Brand names are referenced for demonstration only and do not constitute an endorsement of product.

c. The TurboLite® torch can be screwed directly to a small fuel cylinder or used with hose attachments for reaching remote job sites, and with 1-pound or 7-pound cylinders.

Remote self-lighting torch configurations

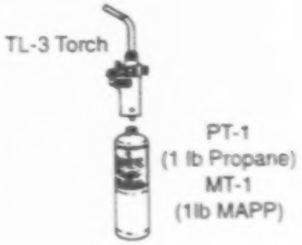


1-pound tank

7-pound refillable tank

TL-3 Torch
SKT-R Reg.
163-01T Adaptor
Propane or MAPP® 1 lb container
TS-12 Hose
TSR Tank rack
TL Series torch
R-LP Reg.
H-12 Hose
163-01T Adaptor
Propane tank T-6PS-MT (empty) MAPP® tank T-6MS-MT (empty)

Self-lighting torch direct-to-cylinder setup



TL-3 Torch
PT-1 (1 lb Propane) MT-1 (1lb MAPP)

Courtesy Victor Equipment Company

Information Sheet

d. The Shurfire™ self-lighting torch from Bernzomatic also offers a swirl tip design for high heat output using a small guel gas cylinder; the Shurfire™ features a pencil flame burntip for detailed work and a general purpose burntip.

e. Dupont Kevlar® is used to make bullet-proof vests, and this lightweight rugged material is used in the Phoenix torch from Phoenix Industries; the Phoenix torch tip will not burn up like some others do, its self-igniting device can be replaced on site, and its B-tank eliminator waist clip makes a small fuel cylinder highly portable.

Information Sheet

f. Smith Equipment Company has made oxyacetylene hoses miniature and highly flexible to work with their Quickfire™ torch; with a standard, double, or triple torch head, the Quickfire™ can deliver a pin-point 6,000°F to really hard-to-reach places, but will not disturb surrounding joints when brazing return bends.

6. Types of acetylene tanks and their applications

a. **B tank** — Used on a portable cart so it can be easily moved to a job site; it holds 40 cubic feet of acetylene to provide fuel enough for a large job

Information Sheet

b. **MC tank** — Can be hand carried for transport to hard-to-reach places; it contains 10 cubic feet of acetylene to provide fuel enough for smaller jobs

Note: Acetylene in smaller containers was used to refill the acetylene headlights in early motor cars, and the initials MC are still used to identify smaller cylinders of acetylene

nters Supp
Applia

c. **LP gas cylinders** — Highly portable cylinders for LP gases such as propane and MAPP®; these cylinders are often used with hand-held, self-igniting torches and are usually a pound or less with some available in larger sizes

7. **Guidelines for lighting, adjusting, and shutting down an air-acetylene torch**

a. Use a tank key or a cylinder wrench to open the acetylene tank valve about a quarter of a turn.

Note: Do not use a crescent wrench or any other kind of wrench on a cylinder.

b. Open the valve on the torch handle and ignite the air/gas mixture with a striker.

Information Sheet

c. Adjust to a neutral flame that has an inner blue cone about ¾″ to 1½″ long.

Note: Flame adjustment will depend on tip size.

d. To extinguish the flame, turn the acetylene tank valve off, let the flame burn itself out, and then close the valve on the torch handle.

8. Equipment required for oxyacetylene welding and brazing

a. Oxygen and acetylene cylinders

b. Pressure regulators for oxygen and acetylene tanks

c. Oxygen and acetylene hoses encased together

d. Welding torch with check valves to prevent flashback

e. Assorted welding/brazing tips

f. Welding goggles and colored safety glasses

g. Sparklighter

h. Cylinder wrench

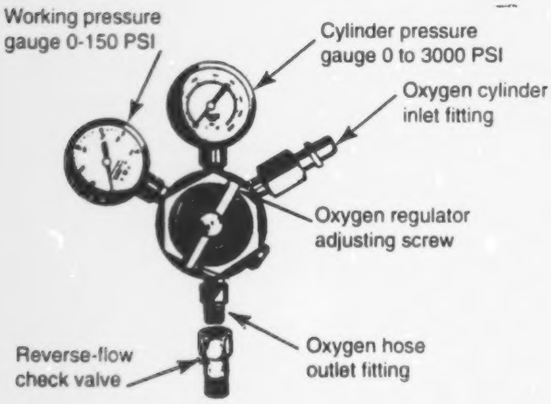
i. Wire brush

Information Sheet

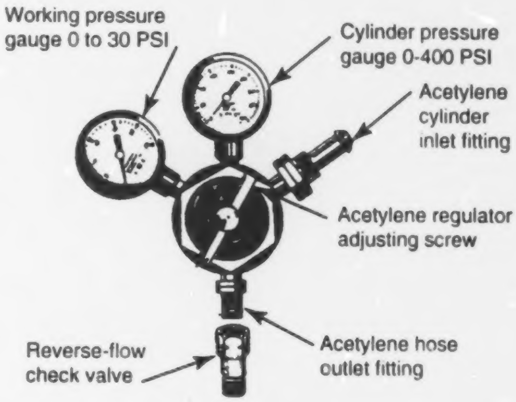
9. **Pressure regulating valves and adjusting screws**

   a. Each regulator, oxygen and acetylene, has two gauges mounted on a single manifold, and one gauge indicates the cylinder pressure and the other gauge indicates working pressure for the torch.

Oxygen Regulator


Working pressure gauge 0-150 PSI
Cylinder pressure gauge 0 to 3000 PSI
Oxygen cylinder inlet fitting
Oxygen regulator adjusting screw
Reverse-flow check valve
Oxygen hose outlet fitting

Acetylene Regulator


Working pressure gauge 0 to 30 PSI
Cylinder pressure gauge 0-400 PSI
Acetylene cylinder inlet fitting
Acetylene regulator adjusting screw
Reverse-flow check valve
Acetylene hose outlet fitting

   b. Each regulator has an adjusting screw so pressure to the torch can be quickly controlled by turning the screw clockwise to increase pressure or counterclockwise to decrease or completely shut off the pressure.

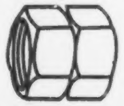
10. **Oxyacetylene hoses and their characteristics**

   a. **Transport** — Special nonporous hoses are used to transfer the gases from the cylinders to the torch

   b. **Color** — Acetylene hoses are always red; oxygen hoses are usually green, but sometimes black

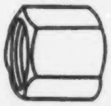
   c. **Connector threads** — Acetylene connectors have a V-groove and left-hand threads, and oxygen connectors have a plain surface and right-hand threads

Acetylene



Left-Hand Threads

Oxygen



Right-Hand Threads

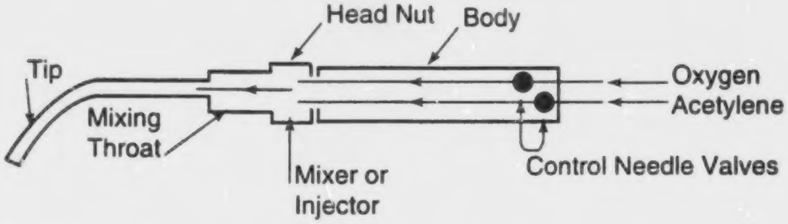
Information Sheet

d. **New hoses** — New hoses are coated inside with a powder to provide protection in storage and new hoses should definitely be purged by attaching them to proper cylinders and opening the regulators to about 5 pounds of pressure

Note: Hose should be purged before a torch is attached to them.

11. Parts of a welding/brazing torch

a. The torch body is designed to be held; it contains two needle valves to control the flow of oxygen and acetylene into the torch.



b. The head contains a mixer or injector, the mixing throat, and the welding tip to control the flame.

12. Oxyacetylene welding/brazing tips and their uses

a. Tips should be selected according to the thickness of the metal workpiece and the type of fuel gas used.

b. The tip selected along with metal thickness also determines operating oxygen/acetylene pressures that should be used.

c. Check manufacturer's guidelines or a tip selection chart for drill size; this indicates the size of the tip when it is new, and the tip cleaner should be selected based on the drill size.

13. Filler material selection for oxyacetylene welding and brazing

a. For both welding and brazing, filler rods and filler materials should have the same or similar properties as the base metal.

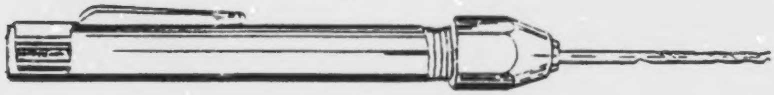
b. As a general rule, the diameter of the filler rod or material should be equal to the thickness of the metal being welded or brazed.

c. When working with a filler rod, bend the end of the rod over to avoid accidental eye injury, and always wear proper eye protection when welding/brazing with oxyacetylene equipment.

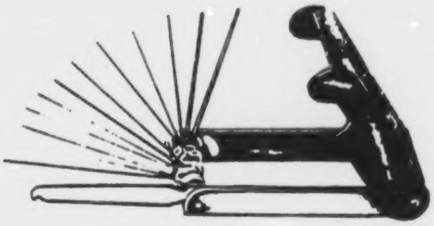
Information Sheet

14. **Tip cleaning tools and their uses**

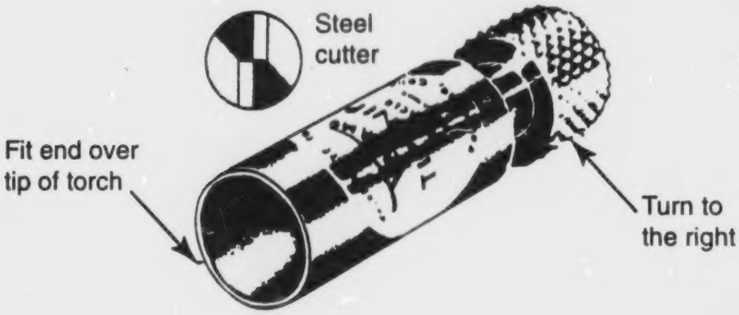
    a. **Tip drill** — A miniature drill used for cleaning and reconditioning orifices



    b. **Tip cleaner** — A device with a series of small file-like probes that are gauged to match specific orifice sizes; used to remove carbon buildup inside a cutting tip



    c. **Tip nip** — A circular device with small steel cutting blades inset so it can be placed over the end of a tip and used to both clean and restore the face of the tip


Steel cutter
Fit end over tip of torch
Turn to the right

Information Sheet

15. Guidelines for cleaning tips

a. Always select a probe smaller than the orifice you're cleaning; never force a cleaning probe into an orifice.

b. Be careful with the seating edges on cutting tips because they can be easily damaged.

c. Clean tips often, and be very careful not to break a probe off inside a tip; they are difficult and time-consuming to remove.

16. Eye protection required for oxyacetylene welding/brazing

a. Wear safety glasses when cleaning or chipping on a base metal, and wear safety glasses plus a face shield when grinding joints or bevels.

b. Wear welding goggles to protect your eyes from spatter, and select a lens shade dark enough to protect your eyes from radiation burns.

Type of Welding	Metal Thickness	Shade #
Brazing	—	3
Light	up to ⅛"	4 or 5
Medium	⅛ - ½"	5 or 6
Heavy	½" +	6 or 8

c. As a general rule, start off with a lens shade too dark to comfortably see the work zone, then move down to a lighter shade that afford a good view of the work zone without straining your eyes.

17. Steps for setting up oxyacetylene equipment

a. Make sure cylinders are chained securely to a cart or wall support.

b. Remove the cylinder caps and clean around the valve threads as required.

c. Stand to one side and open the oxygen cylinder valve momentarily and then close it; repeat the procedure for the acetylene cylinder.

d. Attach the oxygen regulator to the oxygen cylinder and tighten it in place with a cylinder wrench.

e. Attach the fuel gas regulator to the fuel gas cylinder and tighten it in place with a cylinder wrench.

f. Release pressure on both regulators by turning each regulator adjusting screw counterclockwise until tension on the adjusting screws is completely released.

Information Sheet

g. Attach check valves to regulators.

h. Attach hoses to check valves and tighten both with an open end wrench.

i. Purge both hoses by turning each regulator adjusting screw clockwise for about 5 seconds, and then turn counterclockwise to release pressure.

j. Attach hoses to the torch body and tighten them with an open end wrench.

k. Attach a welding/brazing tip to the torch body and tighten finger tight.

l. Turn the torch needle valves clockwise to close them.

m. Set 5 to 10 psi on each regulator by turning the individual adjusting screws clockwise until the working gauge pressure reads the desired pressure.

Caution: Never exceed 15 psi on an acetylene cylinder adjustment!

n. Leak test all threaded connections with leak detector solution that contains no oil.

18. Steps for lighting, adjusting, and shutting down an oxyacetylene torch

a. Make sure all torch valves and all cylinder valves are closed.

b. Open the acetylene cylinder valve slowly about half a turn.

c. Tighten the acetylene regulator adjustment screw until the regulator shows the recommended operating pressure, but never more than 15 psi for acetylene.

d. Open the oxygen cylinder valve slowly counterclockwise as far as it will go.

e. Turn the adjustment screw on the oxygen regulator adjustment screw clockwise until the regulator indicates the recommended pressure for the tip.

f. Take the torch in your dominant hand and point the tip down and away from you.

g. Purge the oxygen line by cracking the oxygen needle valve on the torch until you hear oxygen escaping from the torch, and then slowly turn the oxygen needle valve off.

h. Purge the acetylene line by cracking the acetylene needle valve on the torch until you hear acetylene escaping from the torch, and then slowly turn the acetylene needle valve off.

Information Sheet

i. Keep the torch pointed away from you as you open the acetylene needle valve about a quarter of a turn.

j. Place the sparklighter about an inch from the tip of the torch, squeeze it quickly and firmly, and light the torch.

k. Open the acetylene needle valve until a blue flame appears and carbon smoke diminishes.

l. Open the oxygen needle valve on the torch slowly to allow oxygen to mix with the acetylene.

m. Continue opening the oxygen needle valve until the flame shows a sharp inner cone of fire with no acetylene feather; this is a neutral flame and the best flame to use for brazing.

n. Close the oxygen needle valve on the torch, and then quickly close the acetylene needle valve on the torch.

Note: There are heated discussions about which valve to close first when shutting down an oxyacetylene torch, but the American Welding Society says that which valve is closed first doesn't matter; both valves should be closed as quickly as possible.

o. Close the oxygen and acetylene valves on the cylinders.

p. Open the oxygen needle valve on the torch to bleed the oxygen line, and keep it open until the oxygen regulator returns to zero.

q. Turn the oxygen regulator adjustment screw until spring tension is released, and then close the oxygen needle valve on the torch.

r. Repeat the shutdown procedure for the acetylene side of the system.

s. Secure the equipment.

19. Safety guidelines for flashback and backfire

a. Backfire is momentary backing of the flame into the welding tip and is usually accompanied by a loud pop.

b. Repeated backfire indicates the potential for greater problems and the equipment should be shut down and checked for faulty connections or for soot or dirt in torch mechanisms.

c. Flashback is a continued burning back of the flame in the tip mixer or on into the torch body and it is accompanied by a loud hiss or squeal.

Information Sheet

d. When flashback occurs, immediately shut off the oxygen torch valve, then the acetylene torch valve, and shut the system down completely and check all torch and hose components for damage.

e. Remember the sound, a loud hiss or squeal; it means to shut the system down IMMEDIATELY!

f. Backfire and flashback can both be caused by touching the tip to the work, using the tip too close to the work, or overheating the tip with extended use.

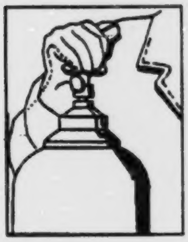
g. An insufficient volume of oxygen or acetylene can also cause backfire and flashback.

h. Dirty seating surfaces, leaks from loose tips, and failure to purge the equipment can also cause backfire and flashback.

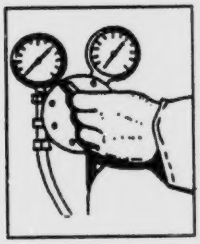
20. Safety rules for oxyacetylene cylinders and gases

Rules and illustrations courtesy Smith Welding Equipment

a. Secure cylinders in a vertical position in a clear area, and blow out the cylinder valves before attaching regulators.

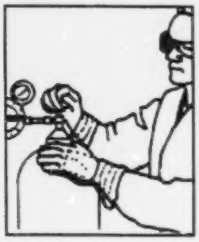


b. Release the adjusting screw on each regulator before opening the cylinder valve.

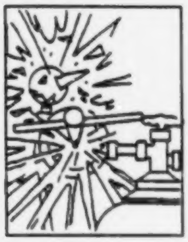


Information Sheet

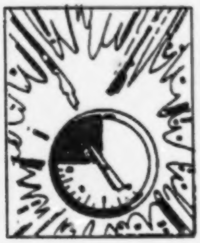
c. Stand to one side opposite the regulator when opening a cylinder valve.



d. Open the cylinder valve slowly to avoid damage to the regulator.

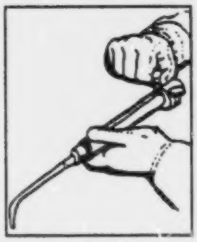


e. Do not set acetylene pressure at more than 15 psi.

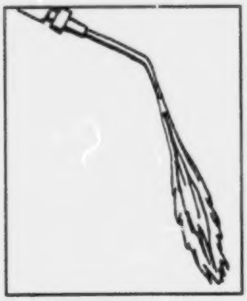


Information Sheet

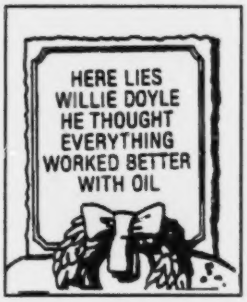
f. Purge oxygen and fuel gas lines before lighting the torch.



g. Open and light acetylene before opening the oxygen valve on the torch.

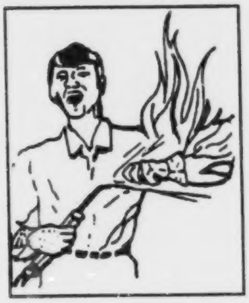


h. NEVER use oil on regulators, torches, fittings, or other equipment that comes in contact with oxygen.

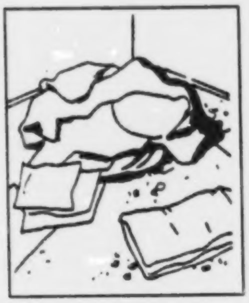

HERE LIES
WILLIE DOYLE
HE THOUGHT
EVERYTHING
WORKED BETTER
WITH OIL

Information Sheet

i. NEVER use oxygen as a substitute for compressed air.



j. Keep heat, flame, and sparks away from all combustibles.



Soldering, Welding, and Brazing Equipment
Unit 7

Job Sheet 1—Light, Adjust, and Shut Down an Air-Acetylene Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Striker used to ignite flame	______
Flame extinguished with proper procedure	______

A. Tools and materials

Air-acetylene torch and tip as selected by instructor
Acetylene tank and tank wrench or alternate fuel as selected by instructor
Friction-type striker
Colored safety glasses

B. Procedure

☐ 1. Put on colored safety glasses.

☐ 2. Open the acetylene tank valve one-quarter turn.

☐ 3. Check torch/tank connections with liquid bubble detector.

Note: Never use a flame to check for a gas leak.

☐ 4. Open the torch handle valve about one-quarter turn.

☐ 5. Strike the striker immediately and light the torch.

☐ 6. Ignite the flame; then open the torch handle valve another half turn.

Caution: If the flame does not ignite immediately, shut the torch handle valve and check with your instructor.

Job Sheet 1

☐ 7. Adjust the flame so that the inner blue cone is about ¾" to 1½".

Note: If there is an air gap between the inner blue cone and the torch tip, the regulator adjusting screw may need to be turned counterclockwise to decrease the pressure.

☐ 8. Allow your instructor to check your flame.

☐ 9. Turn the acetylene tank valve off to extinguish the flame.

☐ 10. Allow the flame to burn itself out, and then close the valve on the torch handle.

☐ 11. Have your instructor check your work.

☐ 12. Secure equipment and return tools and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Soldering, Welding, and Brazing Equipment
Unit 7

Job Sheet 2—Light, Adjust, and Shut Down and Air-Acetylene Torch With a Swirl Tip

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Striker used to ignite flame	______
Flame properly adjusted for swirl tip	______
Flame extinguished with proper procedure	______

A. Tools and materials

Air-acetylene torch and swirl tip as selected by instructor
Acetylene tank and tank wrench or alternate fuel as selected by instructor
Friction-type striker
Colored safety glasses

B. Procedure

☐ 1. Put on colored safety glasses and make sure the swirl tip is in place on the torch.

☐ 2. Open the acetylene tank vaive one-quarter turn.

☐ 3. Check torch/tank connections with liquid bubble detector.

Note: Never use a flame to check for a gas leak.

☐ 4. Push the torch handle button to initiate fuel gas flow.

☐ 5. Strike the striker immediately and light the torch.

> **Caution: If the flame does not ignite immediately, shut the torch handle valve and check with your instructor.**

Job Sheet 2

☐ 6. Adjust the fuel gas regulator so that the flame has a rounded, mushroom head with no feather, and if you can't adjust for the right flame type, check with your instructor.

Caution: Evaluate the flame properly and quickly because anything other than a rounded, mushroom flame could severely damage the tip.

☐ 7. Have your instructor to check your flame.

☐ 8. Turn the acetylene tank valve off to extinguish the flame.

☐ 9. Allow the flame to burn itself out, and then close the valve on the torch handle.

☐ 10. Have your instructor check your work.

☐ 11. Secure equipment and return tools and materials to proper storage.

Evaluator's comments: ______________________________

______________________________ ______________________________

____

Soldering, Welding, and Brazing Equipment
Unit 7

Job Sheet 3—Startup, Light, Adjust, and Shut Down an Oxyacetylene Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Welding goggles and welding gloves properly used	______
Startup pressures properly adjusted	______
Flame properly adjusted to a neutral flame	______
System safely shut down	______

A. Tools and materials

Acetylene tank and oxygen tank
Oxyacetylene torch with welding tip selected by instructor
Friction-type striker
Welding/brazing goggles
Colored safety glasses
Welding/brazing gloves

B. Procedure

☐ 1. Inspect the area to make sure it is free of flammable materials and is well ventilated.

☐ 2. Check your pockets to make sure you are not carrying a cigarette lighter; place it safely aside if you are.

☐ 3. Put on colored safety glasses and welding gloves.

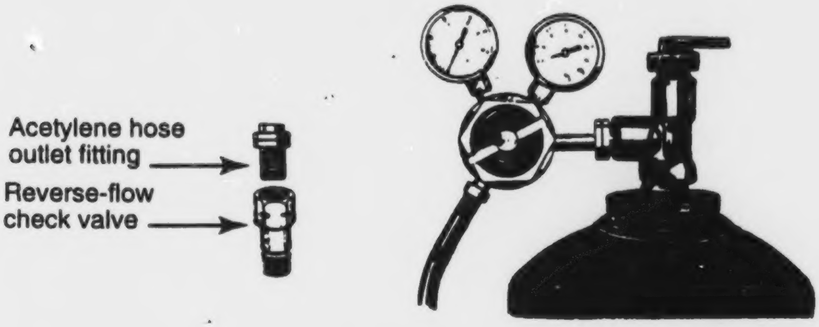
Note: Your instructor may direct you to wear welding goggles.

☐ 4. Inspect the torch valves to make sure they are both turned off, and then open the adjustment screws slightly.

Job Sheet 3

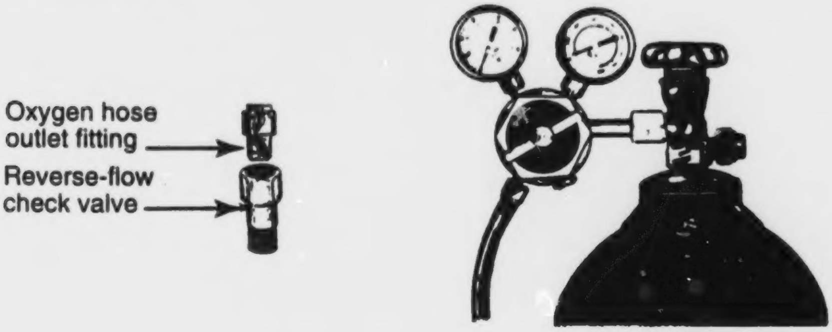
☐ 5. Open the acetylene cylinder valve slowly about half a turn.

Caution: Never open an acetylene cylinder above 15 psi because pressure beyond that point could damage the regulator or cause it to explode, another good reason to stand to one side as you open cylinder valves.


Acetylene hose outlet fitting
Reverse-flow check valve

☐ 6. Tighten the adjustment screw on the acetylene regulator by turning it slowly to the right until the regulator indicates the pressure recommended for the tip you are using; if you cannot find the proper reference in a tip chart, adjust the pressure to 8 pounds.

☐ 7. Open the valve on the oxygen cylinder by slowly turning it to the left as far as it will go.


Oxygen hose outlet fitting
Reverse-flow check valve

Job Sheet 3

☐ 8. Tighten the adjustment screw on the oxygen regulator by turning it to the right until the regulator indicates 10 pounds or the oxygen pressure recommended on the tip chart.

☐ 9. Take the torch in your right hand, even if your left handed, and point the tip down and away from you into a safe area.

☐ 10. Purge the oxygen and acetylene hoses with the following procedure:

> **Caution: To avoid a dangerous build-up of acetylene, only one student at a time should perform this procedure, and the area should be totally free of acetylene before other students attempt the procedure.**

a. Crack the acetylene adjustment screw on the torch with your left hand until you hear acetylene escaping from the end of the tip.

Note: At first the acetylene will make an irregular hissing sound, and then a low, steady hissing sound to indicate that the line is purged.

b. Look at the acetylene regulator to make sure it remains at 8 pounds of pressure or at the beginning pressure you selected.

c. Turn the acetylene adjustment screw on the torch off slowly.

Note: Develop the habit of opening and closing torch adjustment screws slowly with care; forcing them quickly can damage them.

d. Repeat the same procedure with the oxygen line; make sure pressure remains at 10 pounds or at the beginning pressure you selected.

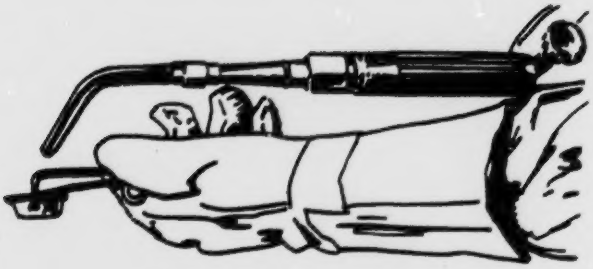
☐ 11. Keep the torch tip pointed down and away form you as you take the sparklighter in your other hand.

☐ 12. Open the acetylene adjustment screw on the torch about a quarter turn.

Note: Acetylene makes a dark, black smoke when it burns, so make the following adjustments as quickly as you can.

Job Sheet 3

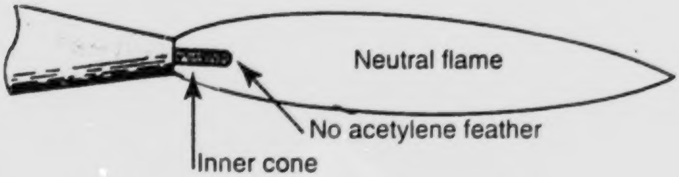
☐ 13. Place the sparklighter about an inch below the torch tip, and squeeze it firmly to make it spark and light the acetylene.



☐ 14. Open the acetylene control valve on the torch until the flame is ¾" away from the tip of the torch where a blue flame should appear as the smoke diminishes.

☐ 15. Open the oxygen control valve on the torch slowly to allow oxygen to mix with the acetylene flame.

☐ 16. Continue opening the oxygen control valve until the mixture and pressure create a sharp, blue inner cone at the torch tip to indicate a neutral flame that is using a proper 1:1 mixture of oxygen/acetylene.



☐ 17. Continue adjusting the oxygen control valve into different positions so you can purpose create improper flames, and then readjust to a neutral flame each time.

☐ 18. Have your instructor check your final neutral flame and pressure settings.

☐ 19. Close the oxygen needle valve on the torch.

☐ 20. Close the acetylene needle valve on the torch.

Note: There are arguments about what should be shut off first, acetylene or oxygen; the American Welding Society recommends shutting the oxygen off first and the acetylene second, but in all cases, according to the AWS, the secret is to shut off both the oxygen and acetylene as quickly as possible.

Job Sheet 3

☐ 21. Close the oxygen valve on the cylinder.

☐ 22. Close the acetylene valve on the cylinder.

☐ 23. Open the oxygen needle valve on the torch to bleed the oxygen line.

☐ 24. Allow the oxygen regulator gauge to return to zero, then turn the oxygen regulator adjustment screw counterclockwise until spring tension is released; then close the oxygen needle valve on the torch.

☐ 25. Repeat the previous procedure for the acetylene line.

☐ 26. Place hoses and torch back on the welding rack and secure all equipment.

☐ 27. Have your instructor check your shutdown procedure.

☐ 28. Secure all equipment and return any materials to proper storage.

Evaluator's comments: ____

____

____

Soft Soldering
Unit 8

Objective Sheet

Unit Objective

After completing this unit, the student should be able to soft solder copper tubing/swage joints in upright, horizontal, and inverted positions with an air-acetylene torch, and soft solder with an oxyacetylene torch. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms relating to soft soldering with their correct definitions.
2. Select true statements about general characteristics of solder.
3. Complete statements about the importance of flux in the soldering process.
4. Solve problems about selecting and applying flux.
5. Solve problems about torch techniques for good soldering.
6. Select true statements about special considerations for soldering.
7. Solve problems about ways to control heat while soldering.
8. Match soldering problems with ways to detect them.
9. Select true statements about soldering and brazing safety.
10. Use an air-acetylene torch to solder copper tubing/swage joints in upright, horizontal, and inverted positions. (Job Sheet 1)
11. Use an oxyacetylene torch to solder copper tubing/swage joints in upright, horizontal, and inverted positions. (Job Sheet 2)

Soft Soldering
Unit 8

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Develop teaching plan. Adjust for different learning styles.
5. Make copies of the Unit Evaluation Form.

Delivery and Application

6. Provide students with unit of instruction.
7. Discuss unit and specific objectives.
8. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
9. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Evaluation

10. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
11. Make copies of the written test. Add or modify test items as needed.
12. Give written test.
13. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.
14. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Introduce Objectives 1 and 2 with samples of types of solder students may be using as they develop soldering skills. Try to find a solder that has a melting range chart in it so that you can demonstrate to students what solidus and liquidus temperatures mean. Skill areas: **Learning skills, learning to learn.**

2. Have different types of flux available to show to students as you discuss Objective 4. Show them a sample of paste flux and demonstrate its use. Skill areas: **Learning Skills, learning to learn.**

3. Take advantage of Objective 5 to demonstrate how to use a soldering torch with traditional techniques, and then show how to manipulate a concentrated heat flame generated by a swirl-type tip. The change from traditional tips to advanced tip design is noted in Job Sheet 1, and students need to be prepared for it. Skill areas: **Foundation skills, science.**

4. Have heat absorbing paste available to demonstrate when you discuss Objective 7. This is a product that's been around awhile, but it needs to be shown to students because it does a good job and is much handier than using a wet or damp cloth to help control soldering heat problems. Skill areas: **Foundation skills, science.**

5. For working samples of regular flux paste and Block-It® heat absorbing paste, contact La-Co Industries, Inc. at 1-800-621-4025, press 1 and then extension 244. The Training Director Jay Lytton indicates that La-Co will provide samples sized large enough that students can work with them. You may also want to ask for other sample materials related to soldering and brazing. Several items are available.

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1994.

3. *Oxyacetylene Welding and Cutting,* 2nd ed. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1992.

Suggested Activities

Suggested Supplemental Resources

1. The American Welding Society dedicates two extensive chapters to soldering and brazing in *Volume 2, Welding Handbook*. This eighth edition covers areas important to all types of soldering and brazing, but much of the material is equally significant for ACR applications, especially materials concerning safety and inspection. For information about the *Welding Handbook*, both *Volume 1* and *Volume 2*, contact:

   The American Welding Society
   550 N.W. LeJeune Road
   Miami, FL 33126

   You can call AWS at 1-800-443-9353 or FAX them at 1-305-443-7559.

2. Special information about lead-free solders developed for potable water systems is available from J. W. Harris Co., Inc. The information is part of *The Serviceman's Guide to Soldering & Brazing*, a pocket-size guide with both soldering and brazing information and several detailed soldering and brazing processes. Write:

   J. W. Harris Company, Inc.
   10930 Deerfield Road
   Cincinnati, OH 45242

   Or call the Harris Company at 1-800-543-4536.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Soft Soldering
Unit 8

Answers to Written Test

1.
   - a. 12
   - b. 10
   - c. 4
   - d. 2
   - e. 7
   - f. 9
   - g. 13
   - h. 11
   - i. 1
   - j. 6
   - k. 5
   - l. 3
   - m. 8

2. b, e, f

3.
   - a. oxides
   - b. below
   - c. solder
   - d. oil, oil

4.
   - a. (2)
   - b. (2)

5.
   - a. (1)
   - b. (2)

6. b, d, e

7.
   - a. (2)
   - b. (2)

8.
   - a. 2
   - b. 5
   - c. 1
   - d. 3
   - e. 4

9. a, b, c, e, f, h

Soft Soldering
Unit 8

Written Test

Name ______________________________ Date ____________________ Score ______

1. Match the terms on the right with their correct definitions.

______a. Alloy added to soft solder to give it added strength

______b. The condition of being tube-like, especially hollow and slender like a hair

______c. The force of adhesion between a solid and a liquid in capillarity, a phenomenon that can cause a liquid to seem to run uphill

______d. A closely fitted joint in soldering where a melted liquid solder flows between two joint surfaces and solidifies to join them

______e. Metal or an alloy melted in the process of joining other metals together

______f. A mildly corrosive substance applied to a joint prior to soldering in order to clean base metals and prevent oxidation of the soldered joint

______g. Any metal component with enough mass to draw heat from an adjacent heat source, a component such as a fitting, valve, or even a compressor near a soldering flame

______h. The lowest temperature at which a metal or alloy is completely liquid

______i. The temperature difference between the solidus and liquidus points of a metal or alloy

1. Melting range
2. Fillet
3. Oxidize
4. Capillary action
5. Solidus temperature
6. Soft soldering
7. Filler metal
8. Tinning
9. Flux
10. Capillarity
11. Liquidus temperature
12. Antimony
13. Heat sink

Written Test

_______j. A metal joining procedure that uses a filler metal that melts at a temperature below 840°F

_______k. The highest temperature at which a metal or allow is completely solid

_______l. To combine with oxygen and rust in such a way to form a film or a scale on metals

_______m. The process of precoating a surface being soldered or brazed so it will better accept the solder or brazing alloy used

2. Select true statements about general characteristics of solder. Place an "X" beside each true statement.

_______a. Solders are available as pure metals or alloys, but most solders are pure metals designed for special service conditions or to comply with local or national codes.

_______b. Lead-base solders cannot be used on potable water lines, but many lead-base solders are still used on drain and vent lines and other applications.

_______c. Solders with lead in them are usually zinc-lead alloys, and it is customary to identify the lead content first when identifying them.

_______d. One lead-free solder that is safe on potable water lines contains 95% tin and 5% zinc which is safe on water and refrigerant lines and actually makes a connection stronger.

_______e. To comply with special restrictions for lines used around food processing equipment, a 95% tin/5% silver solder is often specified because it will not contaminate, has excellent flow qualities, and is strong.

_______f. In all cases where an equipment manufacturer recommends a solder type, that solder should be used for all maintenance and repair because solders are selected according to their solidus and liquidus so that the melting range will be the best one for the application.

Written Test

3. Complete statements about the importance of flux in the soldering process. Circle the material that best completes each of the following statements.

   a. Applying flux to metal components being soldered accelerates the spreading action of the flux and promotes the removal of (**oils**) (**oxides**) that develop as solder is applied.

   b. A good flux should melt at a temperature (**below**) (**slightly above**) the melting temperature of the solder.

   c. Some fluxes such as lead-free "C-Flux" contain a small amount of (**epoxy**) (**solder**) so that the flux not only cleans but promotes "tinning" or better spreading of the solder when it is applied.

   d. Regular flux paste is non-toxic, and can be applied on even an (**oil**) (**rusted**) surface and will allow you to solder through the (**oil**) (**rust**); flux residue can be cleaned off with a damp cloth after soldering is completed.

4. Solve problems about selecting and applying flux. Circle the number of the statement that best solves each of the following problems.

   a. You notice a co-worker applying what looks like too much flux on a connection being repaired. The co-worker says the tubing is oxidized and needs a lot of flux. To correct the problem, the co-worker should:

      (1) Continue applying enough flux to compensate for the condition of the tubing.

      (2) Apply a minimum amount of flux and clean the tubing before applying the flux.

   b. You notice a co-worker has just finished a soldered joint and leaves a flux residue there. The co-worker says the flux will not affect the strength of the joint, but you should:

      (1) Forget it. If the joint was well soldered, it will hold, and the flux residue is unimportant.

      (2) Explain to your co-worker that no matter how strong the joint, the flux residue will contribute to corrosion.

Written Test

5. Solve problems about torch techniques for good soldering. Circle the number beside the statement that best solves each of the following problems.

   a. You have just messed up a soldered joint because you attempted to melt the solder into the joint by directing the torch onto the solder. To correct the problem, you should:

      (1) Clean the joint and start over, but this time, heat the tubing properly and let the heat of the tubing melt the solder.

      (2) Clean the joint and start over, but this time, get the base metal as hot as you can before you apply the torch to the solder.

   b. You are faced with the job of soldering an inverted joint that will literally require the solder you apply to run uphill. To make sure you have no problems, you should:

      (1) Heat the tubing and the fitting at the same time so they will be evenly heated.

      (2) Heat the tubing first, then heat the fitting, and maintain even heat as you apply the solder.

6. Select true statements about special considerations for soldering. Place an "X" beside each true statement.

   ______a. According to *The BOCA® National Mechanical Code*, refrigerant lines should be soldered, not brazed, and although several states have not adopted the BOCA code, many local codes also require refrigerant lines be soldered.

   ______b. There are service situations where the brazing process is unacceptable because the heat generated by the process could damage a nearby valve or connection and cause a sort of domino effect that could impair system operation.

   ______c. In cases where soldering instead of brazing is used on a refrigerant line, the solder selected should be at least a 95/5 to add the extra strength of zinc which will also offer better service with elevated temperatures.

   ______d. Bridgit® is another high-performance lead-free solder developed in response to the Federal ban on using lead-based solders in potable water systems.

   ______e. Stay-Brite® is another tin/silver solder that eliminates the need for high-temperature brazing, but gives the strength of a brazed joint; it is one of the silver-bearing solders approved by the National Sanitation Foundation for use in the food processing industry.

Written Test

7. Solve problems about ways to control heat while soldering. Circle the number beside the statement that best solves each of the following problems.

   a. You're soldering on a job where you know an adjacent valve will act as a heat sink and could be damaged. The quickest way to handle the problem would be to:

      (1) Select a low-heat solder and be careful to confine torch heat to the immediate area of the repair.

      (2) Wet a clean shop cloth or two and throw them over the valve and around the line leading up to the valve.

   b. You need to control heat on both sides of a repair. A wet shop cloth might help, but to be sure, you could:

      (1) Disconnect the line from components, even if it means having to cut the line in two.

      (2) Mold heat absorbing paste upstream and downstream from the repair area.

8. Match soldering problems with ways to detect them. Place the number beside the problem in the blank beside the description of the problem.

   ______a. Evidenced by such thing as lightly pitted surface irregularities in the fillet, caused by overheating the solder itself

   ______b. Evidenced by such things as areas where the metal surface retains its original color, and caused by improper cleaning, improper fluxing, or both

   ______c. Evidenced by such things as areas where solder has flowed across the metal surface, but pulled back to leave a stained surface with globules of solder on it, caused by improper cleaning, improper fluxing, or both

   ______d. Evidenced by such things as the presence of burned flux and surface oxides on the metal

   ______e. Evidenced by such things as poor flow characteristics or lumps of solder stuck to the metal surface

   1. De-wetting
   2. Solder boil spots
   3. Overheating
   4. Underheating
   5. No wetting

Written Test

9. Select true statements about soldering and brazing safety. Place an "X" beside each true statement.

_______a. Perform soldering and brazing processes in a well-ventilated area.

_______b. Use appropriate heat barriers to protect other objects or equipment close to the soldering/brazing area.

_______c. Keep you head away from the fumes generated by heated fluxes and solders.

_______d. Wear regular safety glasses when working with an air-acetylene torch, and wear plain welding goggles when working with an oxyacetylene torch.

_______e. Read labels on fluxes and solder to make sure they are non-toxic, or, if the application demands, lead-free; consult the MSDS information when you're in doubt about any product.

_______f. After handling solder or flux of any kind, be sure to wash exposed skin areas before consuming food.

_______g. Never light an air-acetylene torch or an oxyacetylene torch with anything but a friction-type lighter or a butane lighter.

_______h. Many manufacturers have quit making cadmium-based solders and brazing alloys, but some are still in use; if you have to use such products on a job, be sure to avoid inhaling fumes generated by cadmium because they are toxic.

***Permission to duplicate this test is granted.**

Soft Soldering
Unit 8

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Job Sheet 1—Use an Air-Acetylene Torch to Solder Copper Tubing/Swage Joints in Upright, Horizontal, and Inverted Positions Rating ______

Comments: ______________________

____

Job Sheet 2—Use an Oxyacetylene Torch to Solder Tubing/Swage Joints in Upright, Horizontal, and Inverted Positions Rating ______

Comments: ______________________

____

Other ______________________

____

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

416

*Permission to duplicate this form is granted.

Soft Soldering
Unit 8

Information Sheet

1. **Terms and definitions**

   a. **Antimony** — Alloy added to soft solder to give it added strength

   b. **Capillarity** — The condition of being tube-like, especially hollow and slender like a hair

   c. **Capillary action (or attraction)** — The force of adhesion between a solid and a liquid in capillarity, a phenomenon that can cause a liquid to seem to run uphill

   d. **Fillet** — A closely fitted joint in soldering where a melted liquid solder flows between two joint surfaces and solidifies to join them

   e. **Filler metal** — Metal or an alloy melted in the process of joining other metals together

   f. **Flux** — A mildly corrosive substance applied to a joint prior to soldering in order to clean base metals and prevent oxidation of the soldered joint

   g. **Heat sink** — Any metal component with enough mass to draw heat from an adjacent heat source, a component such as a fitting, valve, or even a compressor near a soldering flame

   h. **Liquidus temperature** — The lowest temperature at which a metal or alloy is completely liquid

   i. **Melting range** — The temperature difference between the solidus and liquidus points of a metal or alloy

   j. **Soft soldering** — A metal joining procedure that uses a filler metal that melts at a temperature below 840°F

   k. **Solidus temperature** — The highest temperature at which a metal or allow is completely solid

   l. **Oxidize**— To combine with oxygen and rust in such a way to form a film or a scale on metals

   m. **Tinning**— The process of precoating a surface being soldered or brazed so it will better accept the solder or brazing alloy used

Information Sheet

2. General characteristics of solder

a. Solders are available as pure metals or alloys, but most solders are alloys designed for special service conditions or to comply with local or national codes.

b. Lead-base solders cannot be used on potable water lines, but many lead-base solders are still used on drain and vent lines and other applications.

c. Solders with lead in them are usually tin-lead alloys, and it is customary to identify the tin content first when identifying them.

Example: A 60/40 solder is 60% tin, 40% lead, and a 50/50 solder is 50% tin, 50% lead.

d. One lead-free solder that is safe on potable water lines contains 95% tin and 5% antimony which is safe on water and refrigerant lines and actually makes a connection stronger.

e. To comply with special restrictions for lines used around food processing equipment, a 95% tin/5% silver solder is often specified because it will not contaminate, has excellent flow qualities, and is strong.

f. In all cases where an equipment manufacturer recommends a solder type, that solder should be used for all maintenance and repair because solders are selected according to their solidus and liquidus so that the melting range will be the best one for the application.

Solder	Tin	Lead	Antimony	Solidus	Liquidus
40/60	40	60	—	360°F	460°F
60/40	60	40	—	360°F	375°F
50/50	50	50	—	360°F	420°F
95/5	95	—	5	452°F	464°F

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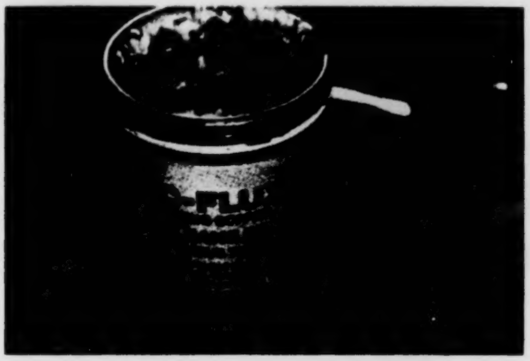
3. The importance of flux in the soldering process

a. Applying flux to metal components being soldered accelerates the spreading action of the flux and promotes the removal of oxides that develop as solder is applied.

b. A good flux should melt at a temperature below the melting temperature of the solder.

Information Sheet

c. Some fluxes such as lead-free "C-Flux" contain a small amount of solder so that the flux not only cleans but promotes "tinning" or better spreading of the solder when it is applied.



Courtesy Rectoseal

d. Regular flux paste is non-toxic, and can be applied on even an oil surface and will allow you to solder through the oil; flux residue can be cleaned off with a damp cloth after soldering is completed.

LA-CO
FLUX
PASTE

Courtesy La-Co Markal Industries, Inc.

4. Selecting and applying flux

a. For AC service, flux may be packaged as a powder, liquid, or paste, and all three types have special applications in AC service.

b. Flux is designed for use with specific alloys, so always follow recommendations of the alloy manufacturer when selecting and applying a flux.

c. Although flux will continue to remove oxides from a metal surface as soldering is taking place, flux is not designed to be used to pre-clean tubing or fittings; metal surfaces must be clean before flux is applied.

Information Sheet

d. Apply flux so that the soldering process will not drive the flux into the interior of the lines; apply the flux only on the sweat allowance at the end of tubing, and keep the flux back from the end of the tubing at least ⅛".

e. After the tubing is fluxed, as long as it can be turned, place it into the fitting and twist it gently back and forth to spread the flux onto the mating surface of the fitting, but do not apply flux to the fitting.

Note: When the tubing is fixed and cannot be twisted around in the fitting, use a soft, acid brush to apply a minimum amount of flux to the mating surface inside the fitting.

f. Apply a minimum amount of flux; too much flux will stop the solder from spreading properly.

g. Excess flux that appears right at the end of a connection after the solder has cooled should be cleaned off so it will not contribute to corrosion.

5. Torch techniques for good soldering

a. Torch techniques for good soldering start with torch selection; bigger jobs may require an oxyacetylene rig, but for most AC line repairs, an air-acetylene torch properly used will do a good job.

Note: Because of the softer flame and lower temperatures it produces, the air-acetylene torch is the best one for the beginner to work with.

b. Size up the job and select a soldering tip that will most efficiently heat the connection; generally, a small tip for small tubing and a large tip for large tubing, but an advanced-design Swirl-jet® or TurboTorch® may provide more concentrated heat that is easier to control.

c. Work only with clean soldering tips because a dirty tip injects soot into the flame and will contaminate a clean workpiece with carbon deposits; clean the tip if it needs it.

d. Adjust to a neutral flame to promote even heating of the base metals to the point where they will melt the solder, and remember to let the base metals melt the solder; do not attempt to melt the solder with the torch flame.

Note: You may have to just touch the tip of the solder with the flame to start it melting, but do not keep the flame on the solder more than a brief moment.

e. After the base metals are heated, back the flame off to maintain heat on the entire connection until the melted solder fills the joint and leaves a bright bead at the point where the tubing and fitting meet.

f. When soldering inverted connections, heat the tubing first and then the fitting and maintain even heat; even when solder is applied below the fitting, capillary action will literally cause the solder to run uphill and fill the joint.

6. **Special considerations for soldering**

a. According to *The BOCA® National Mechanical Code*, refrigerant lines should be brazed, not soldered, and although several states have not adopted the BOCA code, many local codes also require refrigerant lines be brazed.

b. There are service situations where the brazing process is unacceptable because the heat generated by the process could damage a nearby valve or connection and cause a sort of domino effect that could impair system operation.

c. In cases where soldering instead of brazing is used on a refrigerant line, the solder selected should be at least a 95/5 to add the extra strength of antimony which will also offer better service with elevated temperatures.

Information Sheet

d. Bridgit® is another high-performance lead-free solder developed in response to the Federal ban on using lead-based solders in potable water systems.

e. Stay-Brite® is another tin/silver solder that eliminates the need for high-temperature brazing, but gives the strength of a brazed joint; it is one of the silver-bearing solders approved by the National Sanitation Foundation for use in the food processing industry.

Note: The use of brand names is for the purpose of identifying product types and does not constitute endorsement of brand name or product.

7. Ways to control heat while soldering

a. Heat generated by soldering can adversely affect any adjacent valve, fitting, or compressor because these components have mass enough to act as heat sinks, and the heat build-up can destroy internal components.

b. Another problem with a heat sink is that it has a tendency to draw heat away from the soldering area and create a situation where neither flux nor solder reach a proper melting temperature.

c. The fastest way to control heat while soldering is to drape a wet shop cloth over any nearby valve or component that could be a potential heat sink.

Information Sheet

d. Another quick heat control method is to hold a heat absorbing past such as BLOCK-IT® around the tubing upstream or downstream (or both) from the torch flame; the paste acts as a heat sink and protects nearby components.

LACO
BLOC-IT

Courtesy La-Co Markal Industries, Inc.

e. Other heat control methods include using barrier cloth or attaching a heat-barrier shield to the torch tip itself.

f. When a torch flame poses a fire danger to an adjacent wooden frame, spray-on fire retardant works well and is non-toxic even in the presence of heat.

8. **Soldering problems and ways to detect them**

Note: Destructive testing by sawing a joint in half works well in a training lab, but on the job, soldered joints have to be visually inspected.

a. **Solder boil spots** — Evidenced by such things as lightly pitted surface irregularities in the fillet, caused by overheating (boiling) the solder itself

Note: Boil spots do not always mean a soldered joint won't hold, but they do mean the joint may not hold up under heat and pressure.

b. **No wetting** — Evidenced by such things as areas where the metal surface retains its original color, and caused by improper cleaning, improper fluxing, or both

c. **De-wetting** — Evidenced by such things as areas where solder has flowed across the metal surface, but pulled back to leave a stained surface with globules of solder on it, caused by improper cleaning, improper fluxing, or both

d. **Overheating** — Evidenced by such things as the presence of burned flux and surface oxides on the metal

e. **Underheating** — Evidenced by such things as poor flow characteristics or lumps of solder stuck to the metal surface

Information Sheet

9. Soldering and brazing safety

a. Perform soldering and brazing processes in a well-ventilated area.

b. Use appropriate heat barriers to protect other objects or equipment close to the soldering/brazing area.

c. Keep your head away from the fumes generated by heated fluxes and solders.

d. Wear colored safety glasses when working with an air-acetylene torch, and wear colored welding goggles when working with an oxyacetylene torch.

e. Read labels on fluxes and solder to make sure they are non-toxic, or, if the application demands, lead-free; consult the MSDS information when you're in doubt about any product.

f. After handling solder or flux of any kind, be sure to wash exposed skin areas before consuming food.

g. Never light an air-acetylene torch or an oxyacetylene torch with anything but a friction-type lighter, and do not carry a butane lighter in your pocket when using either kind of torch.

h. Many manufacturers have quit making cadmium-based solders and brazing alloys, but some are still in use; if you have to use such products on a job, be sure to avoid inhaling fumes generated by cadmium because they are toxic.

Soft Soldering
Unit 8

Job Sheet 1—Use an Air-Acetylene Torch to Soft Solder Copper Tubing/Swage Joints in Upright, Horizontal, and Inverted Positions

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Mating surfaces cleaned with proper materials	______
Flux and solder properly applied	______
All joints soldered to acceptable service conditions	______

A. Tools and materials

Previously prepared swage joints and appropriate size copper tubing
Fine grade sand cloth or stainless steel brush
Paste flux with low corrosion rating and 50/50 solder
Air-acetylene torch outfit with friction-type striker, or
Other torch/torch tip as selected by instructor
Small wood block with holes for holding various sizes of tubing, or
Other holding device as selected by instructor
Clean, damp shop towel
Safety glasses and colored safety glasses
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

☐ 4. Use the stainless steel brush to clean the mating surface of the copper tubing you will solder into the swage joint, and finish the cleaning with the fine grade sand cloth.

Job Sheet 1

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

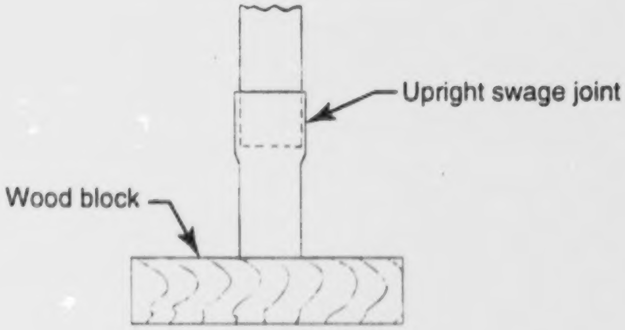
☐ 6. Use a soft, acid brush to apply a thin coat f flux to the mating end of the sweat allowance at the end of the copper tubing.

☐ 7. Insert the copper tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 8. Clean away excess flux with a clean towel.

☐ 9. Place the swage joint into a hole in the wood block or other holder and secure the holder in a vise so that you will be soldering an upright joint.

Note: The wood block will keep the metal vise from acting as a heat sink that could keep the solder from properly wetting and spreading.



☐ 10. Put on colored safety glasses before you work with the air-acetylene torch.

☐ 11. Set up and light the air-acetylene torch and adjust to a neutral flame.

☐ 12. Apply heat to the swage joint with a technique that keeps the inner blue cone of the flame about ⅛" away from the swage joint.

Note: In the event your instructor has elected to have you work with a swirl-type tip, your torch application and technique may vary from the following procedure; adjust your application accordingly or ask your instructor for special directions.

☐ 13. Work the flame slowly around the swage joint and then around the copper tubing, and be sure to keep the torch close enough to heat the entire connection area, but do not overheat the swage or the tubing.

Job Sheet 1

☐ 14. Watch for the flux to form a clear, almost glistening surface on the joint.

☐ 15. Apply solder to the joint at the point where the tubing swage joint, but permit the heat of the copper to melt the solder, do not melt the solder with the flame.

☐ 16. Watch for the solder to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary attraction into the inside of the swage.

☐ 17. Look for a bright, shinny bead to form at the point where the tubing and the swage are soldered; when this fillet forms, it indicates the solder has penetrated the swage and should make a good, solid joint.

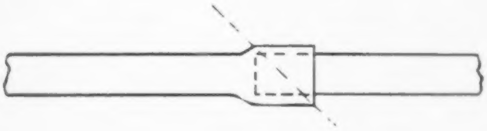
Note: If the solder spreads unevenly or "balls up", it means the joint has been improperly cleaned, improperly heated, or both, so stop the process, reclean the mating surfaces and start over.

☐ 18. Turn off and secure the air-acetylene torch.

☐ 19. Allow the solder to cool; then clean the joint with a clean, damp cloth.

☐ 20. Visually inspect your soldered joint for indications of overheating, underheating, or improper flux or solder application.

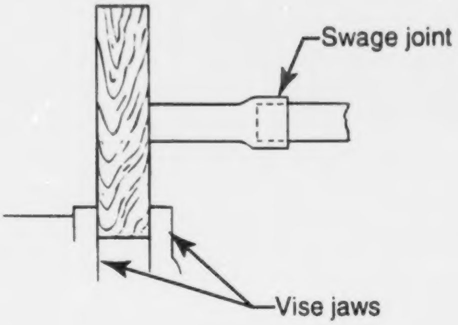
☐ 21. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.



☐ 22. Have your instructor check your upright soldered swage joint.

Job Sheet 1

☐ 23. Repeat the procedure you just completed, but this time, place the swage joint and tubing so that you will be soldering a horizontal joint.

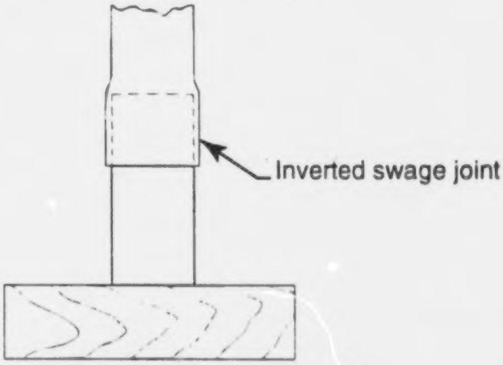


☐ 24. Repeat all steps, and as you solder, note that even at the horizontal, capillary attraction draws the solder into the joint; no solder drips off the tubing (or at least it shouldn't).

☐ 25. Visually inspect the soldered joint for any problems.

☐ 26. Have your instructor check your horizontally soldered swage joint.

☐ 27. Repeat your original procedure, but this time, place the swage joint and tubing so that the swage joint comes down over the tubing to make an "inverted" joint, just the opposite of the joint you made in your initial procedure.



☐ 28. Heat the joint completely and let the solder melt onto the joint; don't try to heat the solder with the torch; allow capillary attraction to work for you because it will literally cause the solder to run uphill and provide a good, solid joint.

Job Sheet 1

☐ 29. Have your instructor inspect your soldered, inverted swage joint.

☐ 30. Secure the air-acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Soft Soldering
Unit 8

Job Sheet 2—Use an Oxyacetylene Torch to Soft Solder Copper Tubing/Swage Joints in Upright, Horizontal, and Inverted Positions

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Mating surfaces cleaned with proper materials	______
Flux and solder properly applied	______
Joint soldered to acceptable service conditions	______

A. Tools and materials

Previously prepared swage joint and appropriate size copper tubing
Fine grade sand cloth or stainless steel brush
Paste flux with low corrosion rating and 50/50 solder
Oxyacetylene torch outfit with friction-type striker, or
Other torch/torch tip as selected by instructor
Small wood block with holes for holding various sizes of tubing, or
Other holding device as selected by instructor
Safety glasses and colored safety glasses
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

☐ 4. Use the stainless steel brush to clean the mating surface of the copper tubing you will solder into the swage joint, and finish the cleaning with the fine grade sand cloth.

Job Sheet 2

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

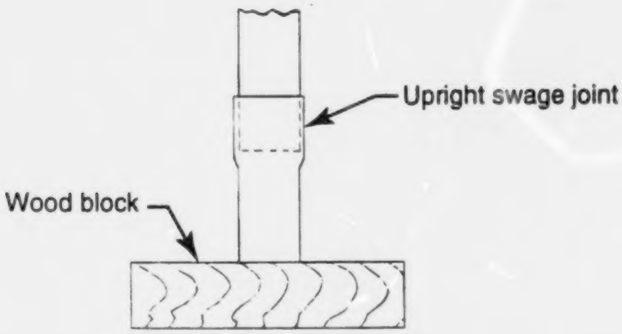
☐ 6. Use a soft, acid brush to apply a thin coat of flux to the mating end of the sweat allowance at the end of the copper tubing.

☐ 7. Insert the copper tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 8. Clean away excess flux with a clean towel.

☐ 9. Place the swage joint into a hole in the wood block or other holder and secure the holder in a vise so that you will be soldering an upright joint.

Note: The wood block will keep the metal vise from acting as a heat sink that could keep the solder from properly wetting and spreading.



☐ 10. Put on colored safety glasses before you work with the air-acetylene torch.

☐ 11. Set up and light the oxyacetylene torch and adjust to a neutral flame.

☐ 12. After obtaining a neutral flame, add more acetylene so that the acetylene feather is about 4″ long, the required setting for soft soldering with oxyacetylene.

☐ 13. Apply heat to the swage joint.

☐ 14. Heat the entire joint by moving the torch flame around it.

☐ 15. Apply solder to the joint.

Note: Do not apply the torch flame directly onto the solder; let the heat from the tubing and swage joint melt the solder and cause it to flow into the joint.

Job Sheet 2

☐ 16. When solder starts to move from out of the joint, immediately withdraw the torch flame and the solder.

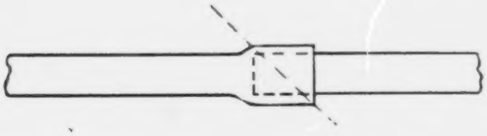
☐ 17. Turn the torch off by first closing the oxygen needle valve on the torch and then closing the acetylene needle valve, and then closing the cylinder valves.

Note: There are discussions about which torch valve to shut off first, oxygen or acetylene. The American Welding Society feels that either valve can be closed first, but the most important thing is to close both valves as quickly as possible.

☐ 18. Allow the solder to cool, and then clean the joint with a damp cloth.

☐ 19. Have your instructor check your upright swage joint.

☐ 20. Cut the swage joint diagonally with a hacksaw.



☐ 21. Have your instructor check the joint again.

☐ 22. Repeat the procedure you just completed, but this time, place the swage joint and tubing so that you will be soldering a horizontal joint.

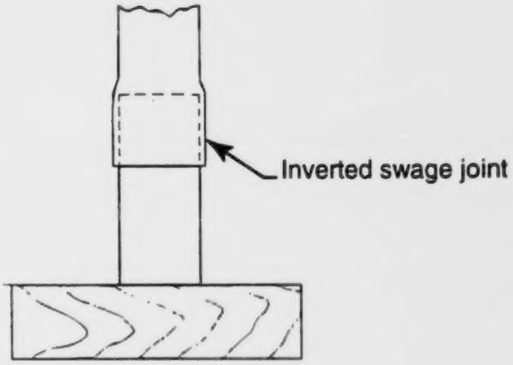
Job Sheet 2

☐ 23. Repeat all steps, and as you solder, note that even at the horizontal, capillary attraction draws the solder into the joint; no solder drips off the tubing (or at least it shouldn't).

☐ 24. Visually inspect the soldered joint for any problems.

☐ 25. Have your instructor check your horizontally soldered swage joint.

☐ 26. Repeat your original procedure, but this time, place the swage joint and tubing so that the swage joint comes down over the tubing to make an "inverted" joint, just the opposite of the joint you made in your initial procedure.



☐ 27. Heat the joint completely and let the solder melt onto the joint; don't try to heat the solder with the torch; allow capillary attraction to work for you because it will literally cause the solder to run uphill and provide a good, solid joint.

☐ 28. Have your instructor inspect your soldered, inverted swage joint.

☐ 29. Secure the air-acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Silver Brazing
Unit 9

Objective Sheet

Unit Objective

After completing this unit, the student should be able to silver braze upright, inverted, and horizontal swage joints and silver braze a copper-to-steel joint. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms relating to silver brazing with their correct definitions.
2. Complete statements about basic silver solder alloys.
3. Match special brazing alloys with their characteristics.
4. Complete statements about brazing fluxes and their applications.
5. Select true statements about controlling brazing oxides with nitrogen.
6. Silver braze upright, inverted, and horizontal swage joints. (Job Sheet 1)
7. Silver braze a copper-to-steel joint. (Job Sheet 2)
8. Silver braze a copper tubing project. (Job Sheet 3)

Silver Brazing
Unit 9

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives.

   TM 1—Melting and Brazing Ranges (Objectives 2 and 3)
   TM 2—Behavior of Flux During Brazing (Objective 4)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

Suggested Activities

14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Use Objectives 2 and 3 to display samples of types of silver brazing alloys students will be working with in the job sheets. Skill areas: **Learning skills, learning to learn.**

2. Integrate materials in Transparency Master 1 with Objectives 1 and 2 to demonstrate the variety of brazing materials and how they are designed for specific applications. Skill areas: **Learning Skills, learning to learn.**

3. Have samples of white or black brazing flux available to show the class when you discuss Objective 4. If you do not have materials presented int he text, use flux that is comparable, and be sure to emphasize that selecting flux is related to the brazing filler material selected for the application. Skill areas: **Foundation skills, science and math.**

4. Have heat absorbing paste available when you demonstrate the procedures in the job sheets. The added heat input required with brazing often demands special considerations for control of heat migration to nearby components that might act as heat sinks. Have students review these materials in Unit 8. Skill areas: **Foundation skills, science.**

5. A job sheet outlining the procedure for circulating nitrogen to control brazing oxides is included as Teacher Supplement 1. If you have facilities to perform the procedure properly, have students complete the process as part of their job sheet assignments. Otherwise, try to arrange for a local demonstration.

6. Review Job Sheet 3 with students. Be sure they have the tubing items from the job sheets in Unit 5. Encourage them to use a ¼" architect's scale to do their measuring. Materials for the architect's scale were presented as a teacher supplement in unit 4. You may want to review that material at this point. Also, demonstrate how to pressure test the assembly with nitrogen. Skill areas: **Foundation skills, math and science.**

Suggested Activities

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.
2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994.
3. *Oxyacetylene Welding and Cutting*, 2nd ed. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1992.

Suggested Supplemental Resources

The Brazing Book published by Handy & Harman, the parent company of Lucas-Milhaupt, Inc., is dedicated to a variety of industrial applications for brazing and brazing products, but much of the material applies to ACR applications, especially a review of "The six basic steps of brazing." For information about *The Brazing Book*, write:

Lucas-Milhaupt, Inc.
5656 S. Pennsylvania Ave.
Cudahy, WI 53110

Lucas-Milhaupt also has a toll-free tech service they call "The Brazing Answer Center." That number is 1-800-558-3856.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Suggested Activities

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Silver Brazing
Unit 9

Answers to Written Test

1.	a.	6	d.	7	g.	5	j.	12
	b.	10	e.	3	h.	1	k.	9
	c.	2	f.	11	i.	8	l.	4

2. a. phosphorous
   b. less
   c. extremely low
   d. high
   e. copper, copper

3. a. 3
   b. 1
   c. 4
   d. 2

4. a. paste
   b. 1600°F
   c. prolonged
   d. 1800°F
   e. brush-cap

5. a, b, c

Silver Brazing
Unit 9

Written Test

Name ______________________ Date ______________ Score _____

1. Match the terms on the right with their correct definitions.

_____a. A substance composed of two or more metals or a metal and a nonmetal

_____b. A number assigned to filler materials by the American Welding Society in order to maintain uniform references to filler metals and alloys; the B that precedes each number stands for "brazing"

_____c. An AWS designation for silver-based alloys; they range from 1 through 7 based on their temperature ranges with BAg-1 starting at 1145°F and BAg-7 starting at 12205°F

_____d. An AWS designation for copper-phosphorous alloys; they range from 2 through 5 based on their temperature ranges with BCuP-2 starting at 1350°F and BCuP-5 starting at 1300°F

_____e. A strengthening alloy sometimes added to silver brazing materials; must be used with care because it creates toxic fumes when melted

_____f. The working name of a commonly used silver brazing alloy that contains 5% silver

_____g. The working name of a silver brazing alloy that contains 15% silver

_____h. The process of joining two metals together with the use of a silver alloy filler material that melts between the range of 1100°F and 1500°F

1. Silver brazing
2. BAg
3. Cadmium
4. QQ and MIL
5. Sil-phos
6. Alloy
7. BCuP
8. Silver brazing flux
9. Troy ounce
10. AWS number
11. Phos-copper
12. Silver solder

Written Test

______i. A white borax paste applied to tubing prior to silver brazing

______j. A brazing alloy that contains a small amount of silver

______k. The pricing unit for silver brazing alloy, based on a weight unit of 12 ounces to the pound

______l. Letters indicating specifications from the federal government or the military

2. Complete statements about basic silver solder alloys. Circle the material that best completes each of the following statements.

   a. The so-to-speak standard alloy for silver brazing is Stay-Silv®-15, an alloy with a 15% silver base with 5% (**phosphorous**) (**antimony**), and is good for all-purpose brazing, especially where joint gap may be difficult to control.

   b. Others of the Sil-Phos brazing alloys include Dynaflow® with 6% silver, 6% phosphorous base, and it is popular because it mirrors the 15% silver-based alloys in applications, but it costs (**less**) (**more**).

   c. Another of the silver, phosphorous alloy group is Phoson+® which has an (**extremely low**) (**medium low**) brazing temperature and is well suited to applications where too much heat could damage packing or other components in nearby valves.

   d. On the other hand, Stay-Sil® 0 is a 7% phosphorous-based alloy which can be used where a (**high**) (**low**) brazing temperature is not critical; its lower cost also makes it a popular filler alloy for brazing.

   e. The phosphorous-bearing alloys are especially handy for working with (**copper**) (**aluminum**) because they are self-fluxing on (**copper**) (**aluminum**).

Written Test

3. Match special silver brazing alloys with their characteristics. Place the number beside the alloy in the blank beside the description of its characteristics.

______a. An alloy with a high 56% silver content alloyed with copper, zinc, and a small amount of tin; bright silver color excellent for food service work area stainless steel

______b. A free-flowing alloy with 40% silver content alloyed with copper and zinc; its silver to light yellow color makes it popular for work with polished brass

______c. A general purpose alloy with a 45% silver content alloyed with copper and zinc; popular for work with brass and often specified in government use

______d. A low-cost alloy with 25% silver with copper, zinc, and tin; good flow properties at low temperatures

1. Safety-Silv®40
2. Safety-Silv®25
3. Safety-Silv®56
4. Safety-Silv®45

4. Complete statements about brazing fluxes and their applications. Circle the material that best completes each of the following statements.

a. Stay-Silv® white brazing flux is designed for use with all silver brazing alloys on all metals except aluminum, magnesium, and titanium; this white (**powder**) (**paste**) is recommended for brazing applications that require normal heat.

b. Stay-Silv® white brazing flux is effective for a temperature range up to (**1200°F**) (**1600°F**).

c. Stay-Silv® black brazing flux is designed for use with heavier parts that require (**prolonged**) (**intense**) heating, and for stainless steel.

d. Stay-Silv® black brazing flux is effective for a temperature range up to (**1500°F**) (**1800°F**).

e. Both white and black brazing fluxes are available in a variety of sizes, and a small (**brush-cap**) (**tube type**) paste container is designed especially for carrying in a tool kit, and is used frequently in brazing kits.

Written Test

5. Select true statements about controlling brazing oxides with nitrogen. Place an "X" beside each true statement.

______a. When brazing activities cover a prolonged period or when they occur at several different points in a single system, oxides that form inside tubing and fittings during brazing can build up in amounts significant enough to impair system performance.

______b. A solution to brazing oxide build-up is to circulate dry nitrogen through the system, or through the affected part of the system, while brazing is in process.

______c. Generally, the nitrogen is fed into the system through a service port or access adjacent to the brazing activity, and vented to the atmosphere so that oxides picked up by the nitrogen will not be recirculated back through the system or a part of the system.

______d. Circulating nitrogen pressure can be as low as 15 or 20 psi, or maybe slightly more, depending on the length of tubing and number of fittings in the circulation run.

***Permission to duplicate this test is granted.**

Silver Brazing
Unit 9

Teacher Supplement 1—Circulate Dry Nitrogen While Silver Brazing a Joint

Note: This supplement is structured as a job sheet so it can be reproduced and used as a student activity as equipment is available for students to work with. Otherwise, it should be discussed with students, or, if possible, arrange with a local AC contractor to demonstrate the nitrogen circulation procedure at a job site and arrange for students to observe.

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Mating surfaces cleaned with proper materials	______
Flux and brazing alloy properly applied	______
Torch technique proper for the application	______
Nitrogen properly circulated during brazing activity	______

A. Tools and materials

Previously prepared swage joint made of copper
Copper tubing sized for copper swage joint
Fine grade sand cloth or stainless steel brush
Silver brazing alloy and flux as selected by instructor
Oxyacetylene torch outfit with selected tip and friction-type striker
Dry nitrogen cylinder with regulator
Clean, damp shop towel
Safety glasses and welding goggles
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the copper swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

Teacher Supplement 1

☐ 4. Use the stainless steel brush to clean the mating surface of the copper tubing you will braze into the swage joint, and finish the cleaning with the fine grade sand cloth.

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

☐ 6. Place the swage joint in a vise (a wood block will keep the vise from acting as a heat sink) and secure it so that the copper tubing will fit into the swage, but leave one end of the copper tubing free to hook up to the nitrogen.

Note: You may want to connect the end of the swage joint to a hose so that the circulating nitrogen can be released out a window or into a pail of water.

☐ 7. Use a soft, acid brush to apply a thin coat of flux to the mating end of the sweat allowance at the end of the copper tubing.

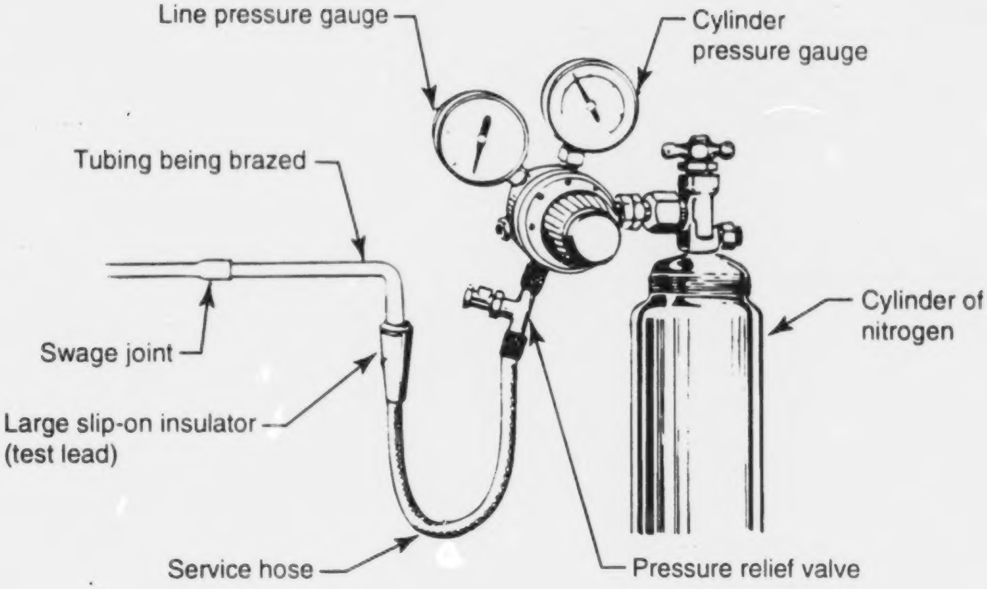
☐ 8. Insert the copper tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 9. Clean away excess flux with a clean towel.

☐ 10. Attach the other end of the copper tubing to the nitrogen cylinder with a hose; improvise the hose connection to the tubing with a large slip-on test lead.

☐ 11. Wrap a damp cloth around the copper tube/hose connection to keep the connection from heating up.

Teacher Supplement 1


Line pressure gauge
Cylinder pressure gauge
Tubing being brazed
Cylinder of nitrogen
Swage joint
Large slip-on insulator (test lead)
Service hose
Pressure relief valve

☐ 12. Put on colored welding goggles so you can work safely with the oxyacetylene torch.

☐ 13. Set the nitrogen regulator at 2 psi and start regulating nitrogen through the line.

☐ 14. Set up and light the oxyacetylene torch and adjust to a neutral flame.

☐ 15. Apply heat to the swage joint with a technique that keeps the inner blue cone of the flame about ⅛″ away from the joint, but keep the torch moving so heat will be distributed equally to all points of the joint.

☐ 16. Let the flux guide you to the proper application temperature; when the flux turns to a clear, almost glistening surface on the joint, move the flame to the base of the socket.

☐ 17. Apply the brazing alloy at the point where the copper tubing and the swage join, but permit the heat of the copper to melt the alloy, do not melt the alloy with the flame.

☐ 18. Watch for the silver alloy to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary action into the inside of the swage.

Teacher Supplement 1

☐ 19. Look for a bright, shinny fillet bead to form at the point where the tubing and the swage are brazed together; when this fillet forms, it indicates the silver has penetrated the swage and should make a good, solid joint.

☐ 20. Turn off and secure the oxyacetylene torch.

☐ 21. Turn off the nitrogen.

☐ 22. Allow the brazed joint to cool, then clean the joint with a clean, damp cloth.

☐ 23. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.

☐ 24. Evaluate the quality of the joint; see if it has coloration or any identifiable difference from other joints that have been cut for evaluation.

☐ 25. Secure the acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Silver Brazing
Unit 9

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Job Sheet 1—Silver Braze Upright, Inverted, and Horizontal Swage Joints Rating ______

Comments: ____

____

Job Sheet 2—Silver Braze a Copper-to-Steel Joint Rating ______

Comments: ____

____

Job Sheet 3—Silver Braze a Copper Tubing Project Rating ______

Comments: ____

____

Other ____

____

Written Tests: Pretest ______ Posttest ______

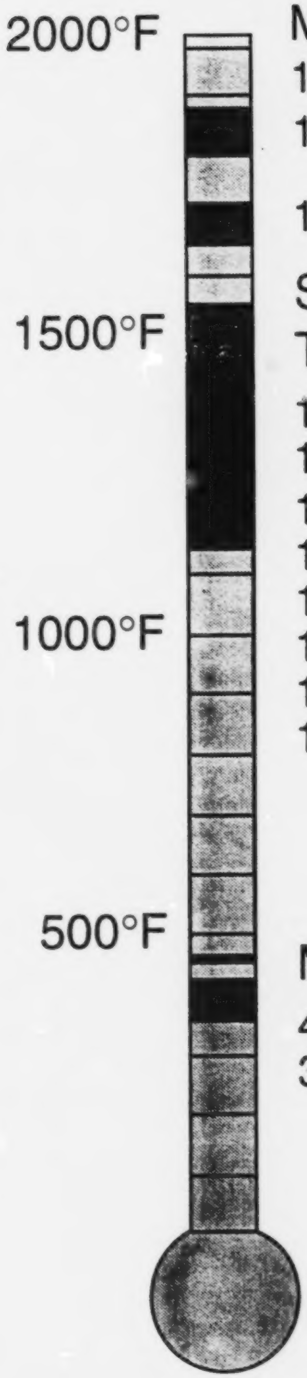
Total ______

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

*Permission to duplicate this form is granted.

Melting and Brazing Ranges



Melting Range

1981 Copper

1810-1880 Red Brass

1660-1710 Yellow Brass

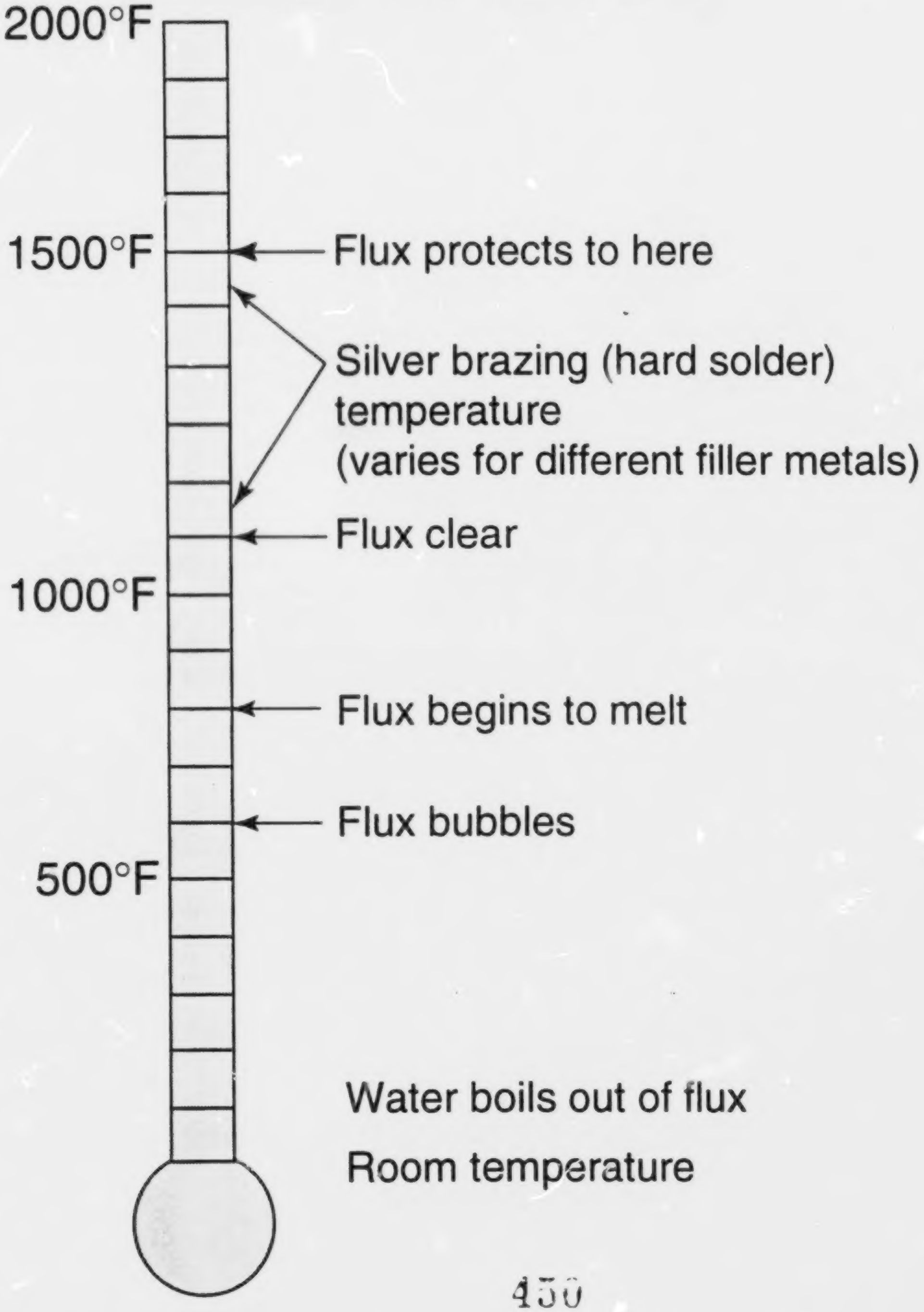
Silver Brazing (Hard Solder)
Temperature Range

1350-1550 BCuP-2 Copper Phos.
1300-1550 BCuP-3 Copper Phos.
1300-1450 BCuP-4 Copper Phos.
1300-1500 BCuP-5 Copper Phos.
1145-1400 BAg-1 Silver
1295-1550 BAg-2 Silver
1370-1550 BAg-5 Silver
1205-1400 BAg-7 Silver

Melting Range (Soft Solder)

452-464 95/5 Tin-Antimony
361-421 50/5 Tin-Lead

Behavior of Flux During Brazing Cycle


2000°F
1500°F
Flux protects to here
Silver brazing (hard solder) temperature (varies for different filler metals)
Flux clear
1000°F
Flux begins to melt
Flux bubbles
500°F
Water boils out of flux
Room temperature

Silver Brazing
Unit 9

Information Sheet

1. **Terms and definitions**

   a. **Alloy** — A substance composed of two or more metals or a metal and a nonmetal

   b. **AWS number** — A number assigned to filler materials by the American Welding Society in order to maintain uniform references to filler metals and alloys; the B that precedes each number stands for "brazing"

   c. **BAg**— An AWS designation for silver-based alloys; they range from 1 through 7 based on their temperature ranges with BAg-1 starting at 1145°F and BAg-7 starting at 12205°F

   d. **BCuP**— An AWS designation for copper-phosphorous alloys; they range from 2 through 5 based on their temperature ranges with BCuP-2 starting at 1350°F and BCuP-5 starting at 1300°F

   e. **Cadmium** — A strengthening alloy sometimes added to silver brazing materials; must be used with care because it creates toxic fumes when melted

   f. **Phos-copper** — The working name of a commonly used silver brazing alloy that contains 5% silver

   g. **Sil-phos** — The working name of a silver brazing alloy that contains 15% silver

   h. **Silver brazing** — The process of joining two metals together with the use of a silver alloy filler material that melts between the range of 1100°F and 1500°F

   i. **Silver brazing flux** — A white borax paste applied to tubing prior to silver brazing

   j. **Silver solder** — A brazing alloy that contains a small amount of silver

   k. **Troy ounce** — The pricing unit for silver brazing alloy, based on a weight unit of 12 ounces to the pound

   l. **QQ and MIL** — Letters indicating specifications from the federal government or the military

Information Sheet

2. Basic silver solder alloys

a. The so-to-speak standard alloy for silver brazing is Stay-Silv®-15, an alloy with a 15% silver base with 5% phosphorous, and is good for all-purpose brazing, especially where joint gap may be difficult to control.

Note: Brand names reference din this objective are for the purpose of presenting product types and does not constitute and endorsement of manufacturer or product; other manufacturers produce these types of products.

b. Others of the Sil-Phos brazing alloys include Dynaflow® with 6% silver, 6% phosphorous base, and it is popular because it mirrors the 15% silver-based alloys in applications, but it costs less.

c. Another of the silver, phosphorous alloy group is Phoson+® which has an extremely low brazing temperature and is well suited to applications where too much heat could damage packing or other components in nearby valves.

d. On the other hand, Stay-Sil® 0 is a 7% phosphorous-based alloy which can be used where a high brazing temperature is not critical; its lower cost also makes it a popular filler alloy for brazing.

e. The phosphorous-bearing alloys are especially handy for working with copper because they are self-fluxing on copper.

ALLOY	SILVER %	PHOS %	MELTING RANGE		FLUIDITY RATING**	RECOMMENDED JOINT CLEARANCE	SPECIFICATION AWS A5.8	FEDERAL QQ-B-654A
			SOLIDUS	LIQUIDUS				
Stay-Silv 0	0	7.10	1310	1475	5	.002/.005	BCuP-2	—
Drynaflow	6	6.10	1190	1465	3	.003/.006	—	—
Stay-Silv 15	15	5.00	1190	1480	3	.003/.006	BCuP-5	BCuP-5 (formerly Grade III)
Phoson +	15	7.30	1190	1205	10	.001/.003	—	—

**High numbers indicate fluidity within the melting range

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3. Special silver brazing alloys and their characteristics

a. **Safety-Sil® 56** — An alloy with a high 56% silver content alloyed with copper, zinc, and a small amount of tin; bright silver color excellent for food service work area stainless steel

Note: Brand names referenced in this objective are for the purpose of presenting product types and does not constitute endorsement of manufacturer or product; other manufacturers produce these types of products.

Information Sheet

b. **Safety-Silv® 40** — A free-flowing alloy with 40% silver content alloyed with copper and zinc; its silver to light yellow color makes it popular for work with polished brass

Note: Both Safety-Silv® 56 and 40 are especially recommended for brazing iron, steel, or other ferrous metals; in fact, phosphorous-bearing alloys should not be used on ferrous metals.

c. **Safety-Silv® 45** — A general purpose alloy with a 45% silver content alloyed with copper and zinc; popular for work with brass and often specified in government use

d. **Safety-Silv® 25** — A low-cost alloy with 25% silver with copper, zinc, and tin; good flow properties at low temperatures

SAFETY-SILV®

	CHEMICAL COMPOSITION					MELTING RANGE			SPECIFICATIONS	
Alloy	Ag	Cu	Zn	Cd	Sn	Solidus	Liquidus	Fluidity Rating*	AWS A5.8	Federal QQB 654A
Safety-Silv® 56	56	22	17	—	5	1145	1200	8	BAg-7	BAg-7
Safety-Silv® 40	40	30.5	29.5	—	—	1150	1350	5	—	—
Safety-Silv® 45	45	30	25	—	—	1250	1370	6.5	BAg-5	BAg-5
Safety-Silv® 45T	45	27	25	—	3	1195	1265	7	—	
Safety-Silv® 25	25	43	30	—	2	1265	1430	6	—	—

*The higher the fluidity rating the faster the alloy flows within the melting range.

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4. brazing fluxes and their applications

a. Stay-Silv® white brazing flux is designed for use with all silver brazing alloys on all metals except aluminum, magnesium, and titanium; this white paste is recommended for brazing applications that require normal heat.

Note: Brand names referenced in this objective are for the purpose of presenting product types and does not constitute an endorsement of manufacturer or product; other manufacturers produce these types of products.

b. Stay-Silv® white brazing flux is effective for a temperature range up to 1600°F.

c. Stay-Silv® black brazing flux is designed for use with heavier parts that require prolonged heating, and for stainless steel.

d. Stay-Silv® black brazing flux is effective for a temperature range up to 1800°F.

e. Both white and black brazing fluxes are available in a variety of sizes, and a small brush-cap paste container is designed especially for carrying in a tool kit, and is used frequently in brazing kits.

Information Sheet

5. Controlling brazing oxides with nitrogen

a. When brazing activities cover a prolonged period or when they occur at several different points in a single system, oxides that form inside tubing and fittings during brazing can build up in amounts significant enough to impair system performance.

b. A solution to brazing oxide build-up is to circulate dry nitrogen through the system, or through the affected part of the system, while brazing is in process.

c. Generally, the nitrogen is fed into the system through a service port or access adjacent to the brazing activity, and vented to the atmosphere so that oxides picked up by the nitrogen will not be recirculated back through the system or a part of the system.

d. Circulating nitrogen pressure can be as low as 2 or 3 psi, or maybe slightly more, depending on the length of tubing and number of fittings in the circulation run.

Note: Circulating nitrogen is difficult to demonstrate in a classroom/lab setting, but your instructor has materials to help you with such an activity if you have equipment and materials available, or a local AC service company may arrange a demonstration for the class.

Silver Brazing
Unit 9

Job Sheet 1—Silver Braze Upright, Inverted, and Horizontal Swage Joints

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Welding goggles worn	______
Mating surfaces cleaned with proper materials	______
Flux and brazing alloy properly applied	______
Torch technique proper for the application	______
Joint brazed to acceptable service condition	______

A. Tools and materials

Previously prepared swage joint and appropriate size copper tubing
Fine grade sand cloth or stainless steel brush
Silver brazing alloy and flux as selected by instructor
Oxyacetylene torch outfit or other torch selected by instructor
Small wood block or other holder for holding tubing
Clean, damp shop towel
Safety glasses and welding goggles
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the copper swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

☐ 4. Use the stainless steel brush to clean the mating surface of the steel tubing you will braze into the swage joint, and finish the cleaning with the fine grade sand cloth.

Job Sheet 1

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

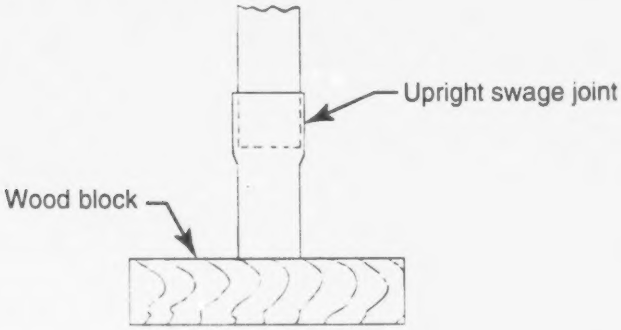
☐ 6. Use a soft, acid brush to apply a thin coat of flux to the mating end of the sweat allowance at the end of the copper tubing.

☐ 7. Insert the copper tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 8. Clean away excess flux with a clean towel.

☐ 9. Place the swage joint into a hole in the wood block or other holder and secure the holder in a vise.

Note: The wood block will keep the metal vise from acting as a heat sink that could keep the brazing from properly wetting and spreading.



☐ 10. Put on colored welding goggles so you can work with the oxyacetylene torch or other selected torch.

☐ 11. Set up and light the torch and adjust to a neutral flame.

☐ 12. Apply heat to the swage joint with a technique that keeps the inner blue cone of the flame about ⅛" away from the swage joint.

☐ 13. Work the flame slowly around the swage joint and then around the copper tubing, and be sure to keep the torch close enough to heat the entire connection area, but do not overheat the swage or the tubing.

☐ 14. Let the flux guide you to the proper application temperature; when the flux turns to a clear, almost glistening surface on the joint, move the flame to the base of the socket.

Job Sheet 1

☐ 15. Apply the brazing alloy at the point where the tubing swage join, but permit the heat of the copper to melt the alloy with the flame.

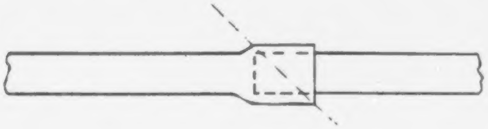
☐ 16. Watch for the silver alloy to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary action into the inside of the swage.

☐ 17. Look for a bright, shinny bead to form at the point where the tubing and the swage are brazed together; when this fillet forms, it indicates the solder has penetrated the swage and should make a good, solid joint.

☐ 18. Turn off and secure the torch.

☐ 19. Allow the brazed joint to cool; then clean the joint with a clean, damp cloth.

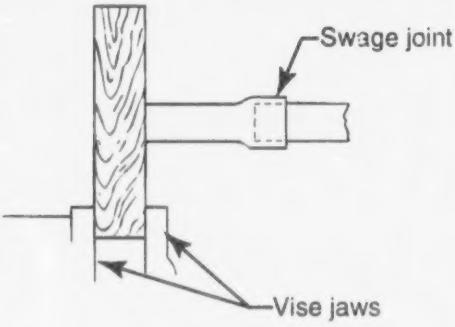
☐ 20. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.



☐ 21. Have your instructor check your upright silver-brazed swage joint.

C. Procedure for silver brazing a horizontal swage joint

☐ 22. Repeat your original procedure again, but this time, place the holder in the vise so that the swage joint is in a horizontal position with the swage part of the connection closest to the vise.



Job Sheet 1

☐ 23. Repeat all steps, but this time, after heating the joint, keep the heat slowly moving on the bottom part of the joint as you start silver brazing.

☐ 24. Turn off and secure the torch.

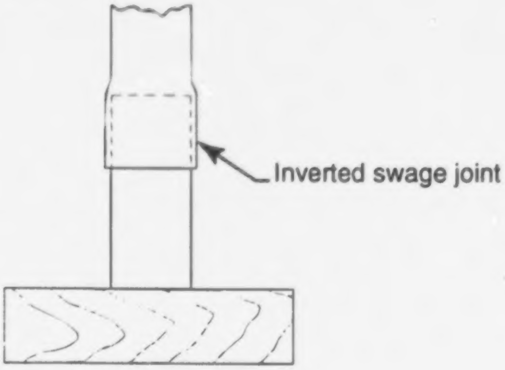
☐ 25. Allow the brazed joint to cool; then clean the joint with a clean, damp cloth.

☐ 26. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.

☐ 27. Have your instructor check your horizontal silver-brazed swage joint.

D. Procedure for silver brazing an inverted swage joint

☐ 28. Repeat the procedure you just completed, but this time, invert the swage joint and tubing in the vise so that the swage joint is on top and will fit down over the tubing.



☐ 29. Repeat all steps, and as you braze, note that even in an inverted position, capillary action draws the silver alloy uphill into the joint; no molten alloy drips off the tubing; if it does drip, you're doing something wrong.

☐ 30. Turn off and secure the torch.

☐ 31. Allow the brazed joint to cool; then clean the joint with a clean, damp cloth.

☐ 32. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.

☐ 33. Have your instructor check your inverted silver-brazed swage joint.

☐ 34. Secure the torch and return tools and materials to proper storage.

Job Sheet 1

☐ 34. Secure the torch and return tools and materials to proper storage.

Evaluator's comments: ______________________________

Silver Brazing
Unit 9

Job Sheet 2—Silver Braze a Copper-to-Steel Joint

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Welding goggles worn	______
Mating surfaces cleaned with proper materials	______
Flux and brazing alloy properly applied	______
Torch technique proper for the application	______
Joint brazed to acceptable service condition	______

A. Tools and materials

Previously prepared swage joint and appropriate size copper tubing
Steel tubing sized for copper swage joint
Fine grade sand cloth or stainless steel brush
Silver brazing alloy and flux as selected by instructor
Oxyacetylene torch outfit or other torch selected by instructor
Small wood block or other holder for holding tubing
Clean, damp shop towel
Safety glasses and welding goggles
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

☐ 4. Use the stainless steel brush to clean the mating surface of the steel tubing you will solder into the swage joint, and finish the cleaning with the fine grade sand cloth.

Job Sheet 2

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

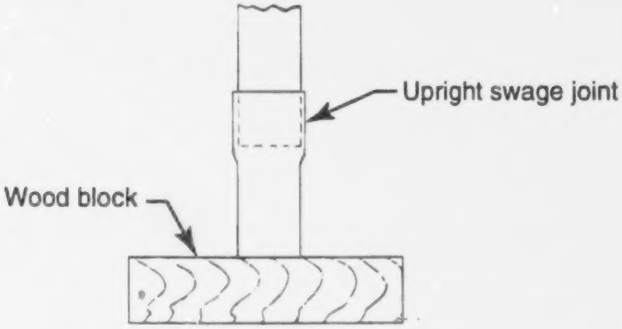
☐ 6. Use a soft, acid brush to apply a thin coat of flux to the mating end of the sweat allowance at the end of the steel tubing.

☐ 7. Insert the steel tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 8. Clean away excess flux with a clean towel.

☐ 9. Place the swage joint into a hole in the wood block or other holder and secure the holder in a vise so that you will be soldering an upright joint.

Note: The wood block will keep the metal vise from acting as a heat sink that could keep the brazing alloy from properly wetting and spreading.



☐ 10. Put on colored welding goggles before you work with the oxyacetylene torch.

☐ 11. Set up and light the oxyacetylene torch and adjust to a neutral flame.

☐ 12. Apply heat to the swage joint with a technique that keeps the inner blue cone of the flame about ⅛″ away from the joint, but concentrate heat on the copper swage and try to keep heat away from the steel because the steel tubing will overheat before the copper is heated enough to accept the molten alloy.

☐ 13. Work the flame slowly around the copper swage with careful attention not to overheat the steel tubing, but yet enough heat to get the copper to the proper temperature.

☐ 14. Let the flux guide you to the proper application temperature; when the flux turns to a clear, almost glistening surface on the joint, move the flame to the base of the socket.

Job Sheet 2

☐ 15. Apply the brazing alloy at the point where the steel tubing and the swage join, but permit the heat of the copper to melt the alloy, do not melt the alloy with the flame.

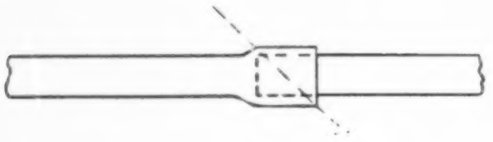
☐ 16. Watch for the silver alloy to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary action into the inside of the swage.

☐ 17. Look for a bright, shinny fillet bead to form at the point where the tubing and the swage are brazed together; when this fillet forms, it indicates the silver has penetrated the swage and should make a good, solid joint.

☐ 18. Turn off and secure the oxyacetylene torch.

☐ 19. Allow the brazed joint to cool; then clean the joint with a clean, damp cloth.

☐ 20. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.



☐ 21. Have your instructor check your upright silver-brazed copper-to-steel swage joint.

☐ 22. Secure the acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Silver Brazing
Unit 9

Job Sheet 3—Silver Braze a Copper Tubing Project

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Welding goggles worn	______
Mating surfaces cleaned with proper materials	______
Flux and brazing alloy properly applied	______
Torch technique proper for the application	______
Project completed with pressure testing	______

A. Tools and materials

Tubing saved from job sheet activities in Unit 5
Other copper tubing as selected by instructor (scrap materials must be usable)
Ts and fitting as selected by instructor
Torch, fuel gas, flux and filler metal selected by instructor
Tubing cutter, stainless steel brush, sand cloth, clean shop cloth
Nitrogen for pressure testing
Measuring tape or rule

B. Procedure

☐ 1. Review the attached diagram of the project assembly and note the scale ratio.

☐ 2. Measure the sections in the project so you will know exactly how much tubing will be required; to duplicate on the jobsite print reading, you may be directed to use a ¼″ architectural scale for your measurements.

☐ 3. Gather tubing from previous job sheets and add other tubing as needed to complete the assembly.

☐ 4. Cut all pieces of tubing and lay them out along with the Ts and your final fitting to make sure you have all the materials you need.

Job Sheet 3

☐ 5. Clean all mating surfaces just prior to brazing them.

Note: This project may consume an extended period; if you clean mating surfaces that you do not braze soon, they will have to be cleaned again later because oxides will form on them.

☐ 6. Swage and braze joints as required, and complete your project as time permits.

☐ 7. Have your instructor make a preliminary check of your project.

☐ 8. Use nitrogen to pressure check your project.

☐ 9. Repair leaks as required.

☐ 10. Have your instructor pressure check and evaluate your project.

☐ 11. Clean area and return tools and materials to proper storage.

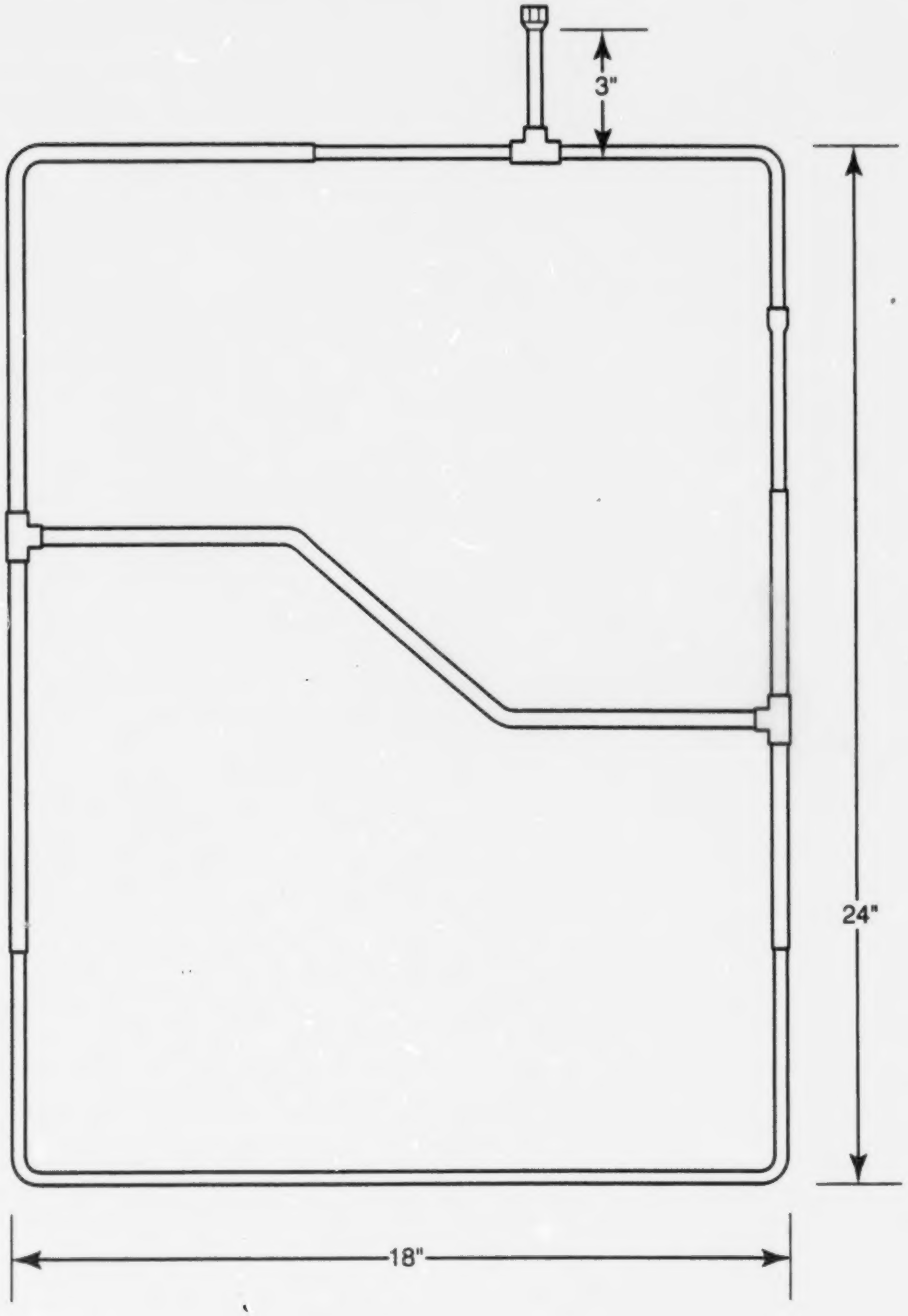
Evaluator's comments: ______________________________

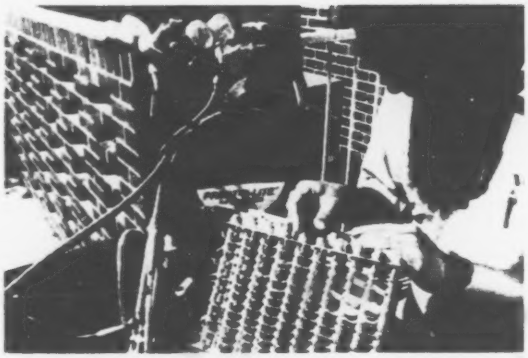
____

____

Job Sheet 3

Project Assembly





Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Objective Sheet

Unit Objective

After completing this unit, the student should be able to solder an aluminum swage joint, braze an aluminum swage joint, and repair aluminum with paste and pre-mixed stick epoxy. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms relating to aluminum soldering, brazing, and epoxy repair with their correct definitions.
2. Complete statements about considerations for aluminum repairs.
3. Solve problems about aluminum repair with epoxy paste.
4. Select true statements about aluminum repairs with pre-mixed epoxy sticks.
5. Complete a list of steps for using the aluminum brazing rod.
6. Complete a list of steps for using aluminum soft solder.
7. Soft solder an aluminum tubing/swage joint with an air-acetylene torch. (Job Sheet 1)
8. Repair a hole in aluminum tubing with brazing and an air-acetylene torch. (Job Sheet 2)
9. Repair a hole in aluminum tubing with paste epoxy. (Job Sheet 3)
10. Repair a pin-hole leak in aluminum tubing with a pre-mixed two-part epoxy stick. (Job Sheet 4)
11. Solder aluminum tubing to copper tubing. (Job Sheet 5)

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparency from the transparency master included with this unit. This appears in the teacher edition only and is designed to be used with the objectives indicated.

   TM 1—Soft Reducing Flame (Objectives 2 and 6)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss and demonstrate the procedures in the job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

Suggested Activities

14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. When the class discusses Objective 2, have samples of materials ready to show to the students and be prepared to demonstrate a soft, reducing flame with both an air-acetylene torch and an oxyacetylene torch. Skill areas: **Learning skills, learning to learn.**

2. Have different types of epoxy on hand to demonstrate as the class discusses Objectives 3 and 4. If you have an ACR service company in your area that does a lot of repairs on aluminum tubing, invite one of the technicians to talk to the class and demonstrate their procedures. Try to arrange a visit to an ACR facility or job site where aluminum repairs are being made and have students form into teams and report the procedures they observe and the types of materials being used. Skill areas: **Group effectiveness skills, teamwork.**

3. For working samples of aluminum flux paste, aluminum solder, and Heat-Seal Stik®, the pre-mixed epoxy repair sticks referenced in this unit, contact La-Co Industries, Inc., at 1-800-621-4025, press 1, extension 244. The Training Manager indicates these materials are available in sample sizes large enough for demonstration and application.

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials.* South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1994.

Suggested Activities

Suggested Supplemental Resources

Omni Technologies Corporation has many products designed for industrial applications in aluminum, but their Sterling Solder is recommended for air conditioning applications, and aluminum boats, aluminum doors and windows, and many other applications. Omni also produces a wide range of silver brazing alloys and copper phosphorous brazing alloys. For their catalog, *Omni Products and Services*, call 603-679-2211, or write:

Omni Technologies Corporation
334 Calef Highway
P.O. Box 820
Epping, NH 03042

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Answers to Written Test

1. a. 2
   b. 5
   c. 1
   d. 4
   e. 3

2. a. solder, braze
   b. Epoxy, epoxy
   c. higher
   d. concentrate
   e. better
   f. liquid

3. a. (2)
   b. (2)

4. a, b, c, e, f, g, h

5. a. patch area
   b. lightly
   c. flux
   d. Melt
   e. liquid
   f. fluxed
   g. brazed area
   h. warm water

6. a. Clean
   b. liquid flux
   c. above, below
   d. solder, flux
   e. dipping
   f. cool
   g. flux residue

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Written Test

Name ______________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions.

______a. An aluminum joining or repair procedure that uses an aluminum alloy rod which melts at a temperature around 1050°F

______b. An aluminum joining or repair procedure that uses a soft wire solder which melts at a temperature about 500°F

______c. A variety of mildly corrosive chemicals used with different types of aluminum brazing and soldering

______d. An aluminum shielded with a protective coating

______e. A thermosetting resin used in adhesives and coatings

1. Aluminum soldering fluxes
2. Aluminum brazing
3. Epoxy
4. Anodized aluminum
5. Aluminum soldering

2. Complete statements about special considerations for aluminum repairs. Circle the material that best completes each of the following statements.

a. Damaged aluminum lines and tubing can be soldered or brazed depending on the nature of the repair; the rule of thumb is to (**solder**) (**braze**) lines and fittings and to (**solder**) (**braze**) leaks in a line.

b. (**Epoxy**) (**Mechanical**) repair for thin aluminum tubing in evaporators and condensers is becoming commonplace, especially on flat plate evaporators where the flat surface area lends itself well to (**epoxy**) (**mechanical**) repair.

c. Aluminum solders generally have (**higher**) (**lower**) melting points than other solders, but still, a soft, reducing flame is recommended for all types of torches used for aluminum soldering and brazing.

d. For aluminum brazing applications, the added heat requirements often demand a special Swirl-Jet® tip or a TurboTorch® tip to (**concentrate**) (**spread**) heat better than a flame that has a feather.

Written Test

e. Because aluminum repairs demand more heat than other soldering and brazing, heat shields are often necessary, and although a wet cloth can usually help, a heat sink paste that can be molded around the line does a (**better**) (**comparable**) job.

f. Repairing aluminum is also different because using powdered flux requires a special routine, and aluminum flux paste, which is really a (**liquid**) (**powder**), is in common use in aluminum soldering.

3. Solve problems about aluminum repairs with epoxy paste. Circle the number beside the statement that best solves each of the following problems.

a. You have been asked to repair a factory package that has an aluminum-to-copper connection that is highly visible. You know the job has to be done on site and poses a real problem unless you:

(1) Clean both mating surfaces really well and use the best grade epoxy you can buy.

(2) Use good epoxy because it works well on dissimilar metals, and be sure to select an epoxy kit that has a coloring agent with it to help you deliver the cosmetic finish you need.

b. You notice that a coworker getting ready to make an aluminum repair with epoxy has sanded the patch area until it is shiny smooth. To correct the problem, you should:

(1) Encourage the coworker to heat the surface and let it cool before applying the epoxy; this will get rid of all scale and make the epoxy adhere better.

(2) Remind your coworker that the repair surface should have a slight roughness to it so the epoxy will adhere better.

4. Select true statements about aluminum repairs with pre-mixed epoxy sticks. Place an "X" beside each true statement.

______a. Because heat poses a problem with aluminum repairs, epoxy sticks that melt in a lower heat range are good choices for patching pin holes and small cracks in aluminum tubing.

______b. A stainless steel wire brush can be used to clean an epoxy patch area, but a good knife blade or even a Scotchbrite® cleaning pad can be used; the idea is to rough it up a bit so that the epoxy will adhere better.

______c. Use solvent to remove oil from the area to be patched because the slightest trace of oil will make epoxy patching impossible.

Written Test

______d. Since system refrigerant has oil in it, a system undergoing a pre-mixed epoxy repair procedure should be placed in a vacuum; a 5" vacuum is best because it assures no system oil will reach the patch area, but isn't vacuum enough to pull epoxy through the patch area and clog the system.

______e. A propane torch delivers plenty of heat for epoxy repair, and the tip selected should provide a softer flame that can be used to kind of "tickle" the repair surface without overheating.

______f. The point of the epoxy stick should be trimmed at a slight angle to give it a wider melting area, and the stick itself should be held between the thumb and forefinger because that provides a bit less pressure than holding the stick as if it were a pencil.

______g. Heat-applied epoxy should be allowed to cool naturally to ambient conditions; any kind of quick cooling or quenching would cause the epoxy to crystallize and negate the repair.

______h. Wear gloves when working with epoxy sticks because a heated epoxy dissipates heat slowly and can cause a severe burn if you get it on your skin.

5. Complete a list of steps for using the aluminum brazing rod. Write in the missing information in the statements that follow.

a. Clean the surfaces of the joint or __________________.

b. Warm the rod end by __________________ brushing it with the torch.

c. Dip the warmed rod end into the __________________.

d. __________________ the flux off the end of the rod onto the joint or patch area.

e. Move the torch in a close, circular motion so it will heat rapidly and turn the flux to __________________.

f. Melt the rod onto the aluminum while keeping the flame on the __________________ area.

g. Allow the __________________ to cool.

h. Remove flux residue with __________________ and a clean cloth.

Written Test

6. Complete a list of steps for using aluminum soft solder. Write in the missing information in each of the following statements.

   a. __________________ the tubing.

   b. Apply a small amount of __________________ to the joint area.

   c. Apply heat __________________ and __________________ the joint by constantly moving the torch back and forth.

   d. Dip the end of the __________________ in the __________________ and apply it to the joint, but be careful not to apply flame directly to the flux.

   e. Continue __________________ the solder into the flux and applying it to the joint as you keep the torch in motion around the joint until the joint is soldered.

   f. Allow the joint to __________________.

   g. Remove __________________ with warm water and a clean cloth.

***Permission to duplicate this test is granted.**

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Job Sheet 1—Soft Solder an Aluminum Tubing/Swage Joint With an Air-Acetylene Torch Rating ______

Comments: ______________________

____

Job Sheet 2—Repair a Hole in Aluminum Tubing With an Air-Acetylene Torch Rating ______

Comments: ______________________

____

Job Sheet 3—Repair a Hole in Aluminum Tubing With Paste Epoxy Rating ______

Comments: ______________________

____

Job Sheet 4—Repair a Pin-Hole Leak in Aluminum Tubing With a Pre-Mixed Two-Part Epoxy Stick Rating ______

Comments: ______________________

____

Job Sheet 5—Solder Aluminum Tubing to Copper Tubing Rating ______

Comments: ______________________

____

Other ______________________

____

Unit Evaluation Form

Written Tests: Pretest ______ Posttest ______

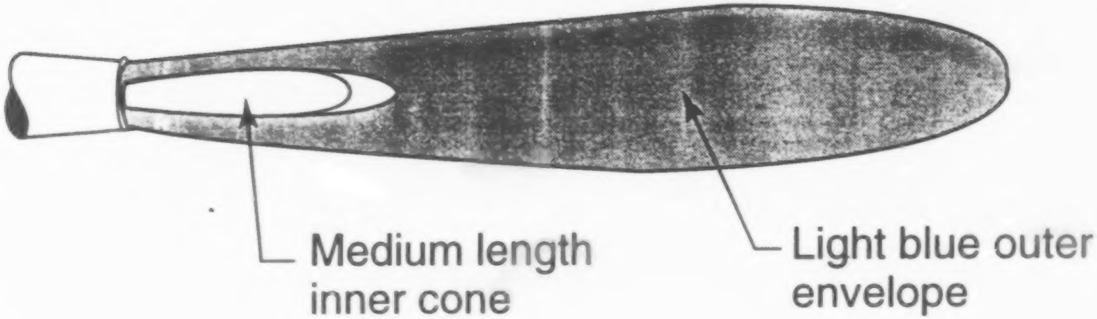
Total ______

Teacher Signature ________________________________ Date ____________

Student Signature ________________________________ Date ____________

*Permission to duplicate this form is granted.

Soft Reducing Flame


Medium length inner cone
Light blue outer envelope

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Information Sheet

1. **Terms and definitions**

   a. **Aluminum brazing** — An aluminum joining or repair procedure that uses an aluminum alloy rod which melts at a temperature around 1050°F

   b. **Aluminum soldering** — An aluminum joining or repair procedure that uses a soft wire solder which melts at a temperature about 500°F

   c. **Aluminum soldering fluxes** — A variety of mildly corrosive chemicals used with different types of aluminum brazing and soldering

   d. **Anodized aluminum** — An aluminum shielded with a protective coating

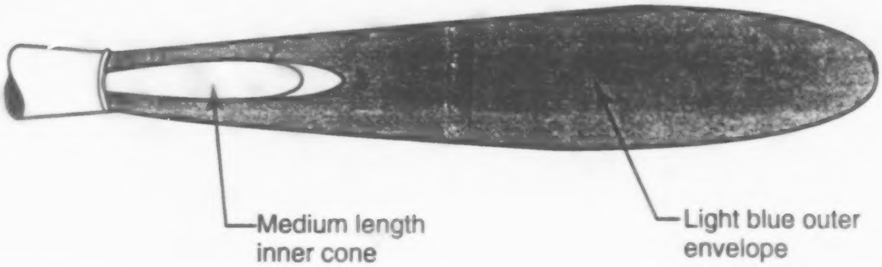
   e. **Epoxy** — A thermosetting resin used in adhesives and coatings

2. **Special considerations for aluminum repairs**

   a. Damaged aluminum lines and tubing can be soldered or brazed depending on the nature of the repair; the rule of thumb is to solder lines and fittings and to braze leaks in a line.

   b. Epoxy repair for thin aluminum tubing in evaporators and condensers is becoming commonplace, especially on flat plate evaporators where the flat surface area lends itself well to epoxy repair.

   c. Aluminum solders generally have higher melting points than other solders, but still, a soft, reducing flame is recommended for all types of torches used for aluminum soldering and brazing.



   d. For aluminum brazing applications, the added heat requirements often demand a special Swirl-Jet® tip or a TurboTorch® tip to concentrate heat better than a flame that has a feather.

Information Sheet

e. Because aluminum repairs demand more heat than other soldering and brazing, heat shields are often necessary, and although a wet cloth can usually help, a heat sink paste that can be molded around the line does a better job.

f. Repairing aluminum is also different because using powdered flux requires a special routine, and aluminum flux paste, which is really a liquid, is in common use in aluminum soldering.

ALUMINUM
FLUX
PASTE

Courtesy La-Co Markal Industries

3. **Aluminum repairs with epoxy paste**

a. Epoxy is an adhesive that has been welcomed in ACR service because it provides a way for fast, reliable repair of the extremely thin aluminum used in evaporators and some condensers.

b. Fabricated aluminum-to-copper tubing connections are extremely difficult to repair on site, but epoxy handles the dissimilar metals repair with no problem.

c. Most epoxy paste is packaged as resin and hardener that have to be mixed and applied in a single procedure.

Information Sheet

d. Other than surface cleaning and mixing, epoxy repair is easy because the patch surface does not have to be heated with a torch.

e. Epoxy kits often have a container with aluminum color that can be mixed in to give exposed lines a clean, cosmetic aluminum look.

f. Use a stainless steel wire brush to clean an epoxy patch area, but when you sand it down, use a rougher grade of sand cloth or a Scotchbrite® pad so the surface will have a slight roughness to which the epoxy will adhere better.

4. Aluminum repairs with pre-mixed epoxy sticks

a. Because heat poses a problem with aluminum repairs, epoxy sticks that melt in a lower heat range are good choices for patching pin holes and small cracks in aluminum tubing.

Note: Epoxy sticks are basic two-part epoxies pre-mixed for low heat repair applications, and they not only work well with aluminum, they work on other metals and even ceramics and glass.

Courtesy La-Co Markal Industries

b. A stainless steel wire brush can be used to clean an epoxy patch area, but a good knife blade or even a Scotchbrite® cleaning pad can be used; the idea is to rough it up a bit so that the epoxy will adhere better.

c. Use solvent to remove oil from the area to be patched because the slightest trace of oil will make epoxy patching impossible.

d. Since system refrigerant has oil in it, a system undergoing a pre-mixed epoxy repair procedure should be placed in a vacuum; a 2" vacuum is best because it assures no system oil will reach the patch area, but isn't vacuum enough to pull epoxy through the patch area and clog the system.

Information Sheet

e. A propane torch delivers plenty of heat for epoxy repair, and the tip selected should provide a softer flame that can be used to kind of "tickle" the repair surface without overheating.

f. The point of the epoxy stick should be trimmed at a slight angle to give it a wider melting area, and the stick itself should be held between the thumb and forefinger because that provides a bit less pressure than holding the stick as if it were a pencil.

g. Heat-applied epoxy should be allowed to cool naturally to ambient conditions; any kind of quick cooling or quenching would cause the epoxy to crystallize and negate the repair.

h. Wear gloves when working with epoxy sticks because a heated epoxy dissipates heat slowly and can cause a severe burn if you get it on your skin.

5. **Steps for using the aluminum brazing rod**

a. Clean the surfaces of the joint or patch area.

Note: When working on a refrigeration system, keep about 5 psi of pressure on the system while cleaning the repair area in order to prevent water or particulate matter from entering the system.

b. Warm the rod end by lightly brushing it with the torch.

c. Dip the warmed rod end into the flux.

d. Melt the flux off the end of the rod onto the joint or patch area.

e. Move the torch in a close, circular motion so it will heat rapidly and turn the flux to liquid.

f. Melt the rod onto the aluminum while keeping the flame on the fluxed area.

g. Allow the brazed area to cool.

h. Remove flux residue with warm water and a clean cloth.

6. **Steps for using aluminum soft solder**

a. Clean the tubing.

b. Apply a small amount of liquid flux to the joint area.

c. Apply heat above and below the joint by constantly moving the torch back and forth.

Information Sheet

d. Dip the end of the solder in the flux and apply it to the joint, but be careful not to apply flame directly to the flux.

e. Continue dipping the solder into the flux and applying it to the joint as you keep the torch in motion around the joint until the joint is soldered.

f. Allow the joint to cool.

g. Remove flux residue with warm water and a clean cloth.

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Job Sheet 1—Soft Solder an Aluminum Tubing/Swage Joint With an Air-Acetylene Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Safety glasses used	_____
Mating surfaces cleaned with proper materials	_____
Flux and solder properly applied	_____
Joint soldered to acceptable service condition	_____

A. Tools and materials

Previously prepared swage joint and appropriate size aluminum tubing
Fine grade sand cloth or stainless steel brush
Aluminum flux with aluminum soft solder
Air-acetylene torch outfit with friction-type striker
Small wood block with holes drilled for holding various sizes of tubing
Clean, damp shop towel
Safety glasses and colored safety glasses
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Clean the inside mating surface of the copper swage joint with a stainless steel brush appropriately sized for the diameter of the swage joint; the object is to remove all oxides on mating surfaces.

☐ 3. Finish cleaning the inside mating surface of the swage joint with fine grade sand cloth.

☐ 4. Use the stainless steel brush to clean the mating surface of the aluminum tubing you will solder into the swage joint, and finish the cleaning with the fine grade sand cloth.

Job Sheet 1

☐ 5. Clean both cleaned mating surfaces with a cloth, and be careful not to leave fingerprints on the swage joint or the tubing.

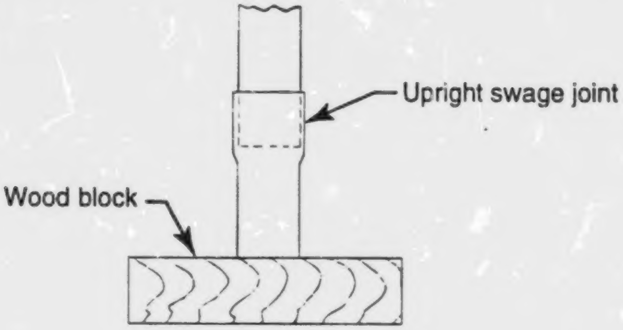
☐ 6. Apply aluminum flux to both parts with a soft, acid brush.

☐ 7. Insert the aluminum tubing into the swage joint and twist the tubing gently back and forth a couple of times to spread the flux onto the mating surface of the swage.

☐ 8. Clean away excess flux with a clean towel.

☐ 9. Place the swage joint into a hole in the wood block and secure the wood block in a vise.

Note: The wood block will keep the metal vise from acting as a heat sink that could keep the solder from properly wetting and spreading.



☐ 10. Put on colored safety glasses before you work with the air-acetylene torch.

☐ 11. Set up and light the air-acetylene torch and adjust to a neutral flame.

☐ 12. Apply heat to the swage joint with a technique that keeps the inner blue cone of the flame about $\frac{1}{8}$" away from the swage joint.

☐ 13. Work the flame slowly around the swage joint and then around the copper tubing, and be sure to keep the torch close enough to heat the entire connection area, but do not overheat the swage or the tubing.

Note: Aluminum is very easy to overheat!

☐ 14. Watch for the flux to form a clear, almost glistening surface on the joint.

Job Sheet 1

☐ 15. Dip the solder into the flux and the apply solder to the joint at the point where the tubing swage join, but permit the heat of the copper to melt the solder with the flame.

☐ 16. Watch for the solder to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary attraction into the inside of the swage.

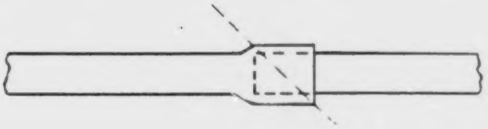
☐ 17. Look for a bright, shinny bead to form at the point where the tubing and the swage are soldered; when this fillet forms, it indicates the solder has penetrated the swage and should make a good, solid joint.

Note: If the solder spreads unevenly or "balls up", it means the joint has been improperly cleaned, improperly heated, or both, so stop the process, reclean the mating surfaces and start over.

☐ 18. Turn off and secure the air-acetylene torch.

☐ 19. Allow the solder to cool; then clean the joint with a clean, damp cloth.

☐ 20. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.



☐ 21. Have your instructor check your soldered swage joint.

☐ 22. Secure the air-acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Job Sheet 2—Repair a Hole in Aluminum Tubing With Brazing and an Air-Acetylene Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Safety glasses used	______
Mating surfaces cleaned with proper materials	______
Flux and solder properly applied	______
Joint soldered to acceptable service condition	______

A. Tools and materials

Aluminum tubing or component as selected by instructor
Fine grade sand cloth or stainless steel brush
Aluminum flux with an aluminum brazing rod
Air-acetylene torch outfit with friction-type striker
Clean, damp shop towel
Colored safety glasses

B. Procedure

☐ 1. Put on colored safety glasses.

☐ 2. Punch a hole in the tubing you plan to repair, or use an existing hole in a component supplied by your instructor.

☐ 3. Use a stainless steel brush to clean the surface around the hole in an area at least ½" away from the area of the hole.

☐ 4. Finish cleaning the area with fine grade sand cloth, and wipe the area with a clean shop towel.

Note: If you are cleaning an aluminum evaporator or condenser, tilt it so that any oil in the component will drain away from the area where you intend to apply heat.

Job Sheet 2

☐ 5. Warm one end of the brazing rod and dip the warmed end into the flux.

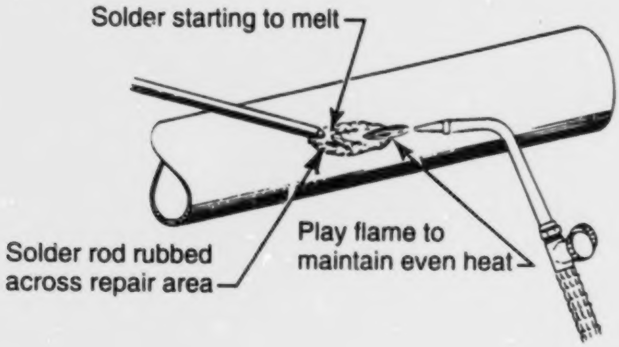
☐ 6. Melt flux off of the brazing rod onto the area you intend to braze patch.

☐ 7. Keep the torch in motion, and heat the patch area rapidly until the flux turns to a glistening liquid.

Note: Aluminum is easy to overheat, and since aluminum does not change color when it is heated, overheating can be a real problem.

☐ 8. Melt the brazing rod onto the aluminum while keeping the flame on the fluxed area.

☐ 9. Rub the brazing rod over the entire patch area as the solder begins to melt.


Solder starting to melt
Solder rod rubbed across repair area
Play flame to maintain even heat

☐ 10. Keep the torch in motion until the entire patch area is covered with alloy.

☐ 11. Shut the torch down and secure it as you permit the brazing to cool.

☐ 12. Remove flux residue with warm water and a clean cloth.

☐ 13. Have your instructor check the brazed patch area.

Note: At the option of your instructor, you may be asked to pressurize the tubing or component you patched to see if it has leaks. Your instructor will guide you through that procedure.

☐ 14. Secure air-acetylene torch and return tools and materials to proper storage.

Job Sheet 2

☐ 15. Work the flame slowly around the swage joint and then around the copper tubing, and be sure to keep the torch close enough to heat the entire connection area, but do not overheat the swage or the tubing.

Note: Aluminum is very easy to overheat!

☐ 16. Watch for the flux to form a clear, almost glistening surface on the joint.

☐ 17. Dip the solder into the flux and then apply solder to the joint at the point where the tubing and the swage join, but permit the heat of the copper to melt the solder, do not melt the solder with the flame.

☐ 18. Watch for the solder to start spreading around the joint area; it should melt around the rim of the swage joint and be drawn by capillary attraction into the inside of the swage.

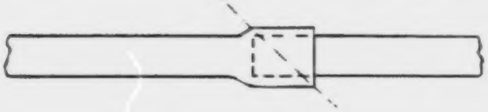
☐ 19. Look for a bright, shinny bead to form at the point where the tubing and the swage are soldered; when this fillet forms, it indicates the solder has penetrated the swage and should make a good, solid joint.

Note: If the solder spreads unevenly or "balls up", it means the joint has been improperly cleaned, improperly heated, or both, so stop the process, reclean the mating surfaces and start over.

☐ 20. Turn off and secure the air-acetylene torch.

☐ 21. Allow the solder to cool; then clean the joint with a clean, damp cloth.

☐ 22. Keep the joint secured in the vise and use a hacksaw to cut the joint on a diagonal.



☐ 23. Have your instructor check your soldered swage joint.

☐ 24. Secure the air-acetylene torch and return tools and materials to proper storage.

Evaluator's comments: ______________________________

____

____

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Job Sheet 3—Repair a Hole in Aluminum Tubing With Paste Epoxy

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Safety glasses used	______
Aluminum surface cleaned with proper materials	______
Epoxy, catalyst, and coloring properly mixed	______
Repair made to acceptable service condition	______

A. Tools and materials

Aluminum tubing or component as selected by instructor
Fine grade sand cloth or stainless steel brush
Epoxy kit with catalyst and mixing spatula
Tube of aluminum gray coloring
Vial of epoxy cleaning solvent
Clean shop towel
Safety glasses

B. Procedure

☐ 1. Put on colored safety glasses.

☐ 2. Punch a hole in the tubing you plan to epoxy, or use an existing hole in a component supplied by your instructor.

☐ 3. Use a stainless steel brush to clean the surface around the hole in an area at least ½″ away from the area of the hole.

☐ 4. Finish cleaning the area with fine grade sand cloth, and wipe the area with a clean shop towel.

☐ 5. Open the epoxy and the catalyst and spread a small amount of each to one side of the patch area.

Note: Keep your head safely away from the epoxy and catalyst fumes.

Job Sheet 3

☐ 6. Use the spatula to mix the two components until they appear to have a single consistency.

☐ 7. Add a small amount of aluminum gray coloring to the mixture and mix it into the epoxy/catalyst mixture; add coloring as needed to give the patch a true aluminum color.

☐ 8. Spread the mixture over the patch area until it leaves an even coat over the entire patch area, and be sure outside edges fully adhere to the aluminum.

☐ 9. Open the vial of cleaning fluid and clean any excess mixture from the patch area.

☐ 10. Give the patch at least 15 minutes to dry.

☐ 11. Clean the spatula with cleaning fluid, and cap all containers.

☐ 12. Have your instructor check your epoxy patch.

☐ 13. Deposit the cloth wet with cleaning fluid in a safe disposal area.

☐ 14. Secure the epoxy kit and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Job Sheet 4—Repair a Pin-Hole Leak in Aluminum Tubing With a Pre-Mixed Two-Part Epoxy Stick

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Area around pin-hole leak properly prepared	______
Proper vacuum maintained on system during repair	______
Epoxy properly applied and leak repair verified	______

A. Tools and materials

Manifold gauge set
Vacuum pump
Stainless steel wire brush
Propane torch outfit
Pre-mixed two-part epoxy stick (La-Co Heat Seal Stick® or equivalent)
Clean shop cloth
Aluminum evaporator or condenser coil with pin-hole leak or small crack
(Coil should be in a sealed system that can be put under a vacuum)
Safety glasses and gloves

B. Procedure

☐ 1. Put on safety glasses and gloves.

☐ 2. Make sure system is off, and check your watch; take as long as you need to properly complete the procedure, but when you finish you'll have an opportunity to compare your time with an approximate time that a professional would need to complete this same job.

Job Sheet 4

☐ 3. Remove any surface oil with solvent and a clean rag. and then use a stainless steel brush to lightly rough up the aluminum surface so that the epoxy will have a good bonding surface.

☐ 4. Hook up the vacuum pump to the system, turn the system on, and pull 2" of vacuum on the system, and leave the system under vacuum until you have completed this repair (the 2" vacuum will keep system oil from interfering with the epoxy patch, but more than a 2" vacuum could pull the patch material into the line and block the system).

YELLOW JACKET

Job Sheet 4

☐ 5. Light the torch and start lightly heating the areas around the pin hole or crack, but do not put the flame directly on the damaged area or onto the epoxy stick, and remember that this is not a brazing process; you want gentle, controlled heat.

☐ 6. Start with a fresh heat seal epoxy stick, or the clean end of a preused stock (make sure it looks dry), lightly touch the stick down on the surface you have heated and begin to move the stock very lightly in a circle.

Note: Cut the end of the stick at an angle to give a wider melting area.

☐ 7. Use the stick as a temperature indicator; as the epoxy begins to melt, continue with a light circular and criss-cross pattern to place the epoxy around and over the damaged area.

Note: If you hold the epoxy stick like you hold a pencil, you may have a tendency to press down too hard. Hold the stick lightly between your thumb and forefinger to avoid too much downward pressure.

☐ 8. As you work the epoxy over the pin hole or crack, be careful not to push the material into the hole (this could plug the line), but rather, create a thin coating with continued light circular or criss-cross movements (the stick should move smoothly as the epoxy melts onto the patch area).

Note: Imagine that the repair area is marked with an X. Bounce the flame lightly right and left of the X to keep the repair area properly heated.

☐ 9. Watch the color at the end of the epoxy stick; at this point is should be the same color as the color of the epoxy you have applied to the patch area.

☐ 10. Begin to feather or "tickle" the surface in a circular pattern with the tip of the flame.

Note: If the epoxy over the patch area starts bubbling or turns black, the patch will not be a good one; let the area cool, reclean, and start over.

☐ 11. Continue to "feather" the epoxy you have just applied, meaning kind of tickle it with the flame, and watch for the material on the patch to begin to smooth out and change from the color of the epoxy stick to an olive drab green.

☐ 12. As the repaired surface beings to turn to olive drab green, take the heat away and shut off the torch, and allow the patch to cool naturally to ambient temperature.

Job Sheet 4

☐ 13. As the repaired surface cools, chip off the hard material at the end of the epoxy stick until the end of the stick looks clean and dry so that it will be ready for use on the next epoxy job.

☐ 14. Release the vacuum on the system, and put the manifold gauge set and the vacuum pump in a safe storage area.

Note: Check you watch now and approximate the time you spend completing this procedure. If you made it in 3 minutes or less on a first try, you did a fine job. As your speed improves, you should easily match the professional time of about 2 minutes, sometimes a few seconds less.

☐ 15. Have your instructor check your epoxy patch.

☐ 16. Return the torch outfit and other materials to proper storage.

Evaluator's comments: ____

____

____

Aluminum Soldering, Brazing, and Epoxy Repair
Unit 10

Job Sheet 5—Solder Aluminum Tubing to Copper Tubing

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Work surfaces cleaned with proper materials	______
Flux properly applied	______
Repair made to acceptable service conditions	______

A. Tools and materials

Aluminum and copper tubing selected by instructor
Fine grade sand cloth or stainless steel brush
Aluminum brazing rod and flux
Air-acetylene or other torch selected by instructor
Clean shop cloth
Colored safety glasses
Tools for swaging copper tubing
Hacksaw

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Cut pieces of aluminum and copper tubing 3″ long.

☐ 3. Ream one end of the copper tubing and prepare it as a swage.

☐ 4. Clean the swage socket with sanding cloth.

☐ 5. Clean the mating end of the aluminum tubing with a stainless steel wire brush and then sand with sand cloth.

☐ 6. Apply a small amount of flux to the aluminum tubing.

Job Sheet 5

☐ 7. Insert the aluminum tubing into the copper swage socket and twist the tubing to spread the flux around the tubing and the swage socket.

☐ 8. Place the tubing in a holding device and then secure it in a vise.

☐ 9. Light the torch and adjust for a soft, reducing flame.

☐ 10. Dip one end of the solder into the flux.

☐ 11. Start moving the torch in a slow, circular motion to heat the swage and the tubing.

☐ 12. Touch the solder to the heated joint until it begins to flow into the joint, and continue to dip the end of the solder in the flux from time to time.

☐ 13. Continue to touch the solder to the heated joint until solder flows all the way around the joint.

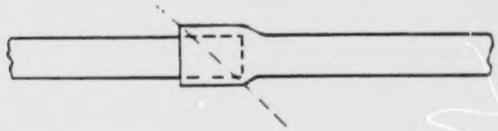
☐ 14. Remove the flame and turn off the torch.

☐ 15. Allow the solder to cool.

☐ 16. Dampen a shop cloth and clean the joint.

☐ 17. Have your instructor check your work.

☐ 18. Cut the swage joint on the diagonal with a hacksaw.



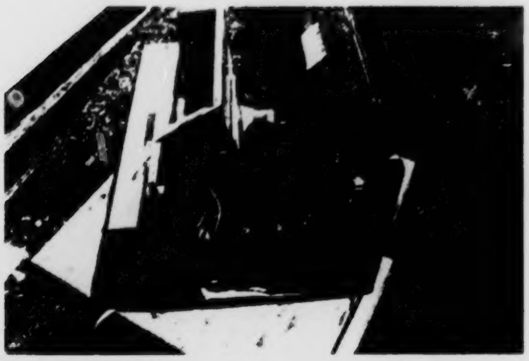
☐ 19 . Have your instructor check the cut joint.

☐ 20. Secure the torch and return tools and materials to proper storage.

Evaluator's comments: ____

____

____



Basic Mechanical Refrigeration
Unit 11

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify components of a basic mechanical refrigeration system, select component functions in a basic refrigeration cycle, and find and identify basic refrigeration components. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms relating to basic mechanical refrigeration with their correct definitions.
2. Match major refrigeration system components with their functions.
3. Complete statements about how laws for thermodynamics and gases work in a refrigeration cycle.
4. Select true statements about reciprocating compressors and their applications.
5. Complete statements about other compressors and their applications.
6. Identify types of metering devices and their characteristics.
7. Identify types of condensers and their characteristics.
8. Identify types of evaporators and their characteristics.
9. Solve problems about system design and sensory troubleshooting.
10. Identify components of a basic mechanical refrigeration system. (Assignment Sheet 1)
11. Select component functions in a basic refrigeration cycle. (Assignment Sheet 2)
12. Find and identify basic refrigeration components. (Job Sheet 1)

Basic Mechanical Refrigeration
Unit 11

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparency from the transparency master included with this unit. This appears in the teacher edition only and is designed to be used with the objectives indicated.

   TM 1—Mechanical Refrigeration System (Objectives 2, 3, and 4)

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss and demonstrate the procedures in the assignment and job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Have a basic mechanical refrigeration system in operating condition available to physically show components as they are presented in Objective 2. Skill areas: **Learning skills, learning to learn.**

2. Demonstrate how to access a basic refrigeration system with a manifold gauge set, and use the set to demonstrate operating pressures on the high/low sides of the system so students will be able to relate system dynamics to something they can see. Remind students that Assignment Sheet 1 will test their knowledge of system dynamics and that they will be required to show system conditions by using dotted lines to separate inside/outside components, high/low pressures, and liquid/vapor conditions. Skill areas: **Foundation skills, science and math.**

3. Have components available to demonstrate metering devices, condensers, and evaporators as they appear in Objectives 6, 7, and 8. Point out how technical design of these components has enhanced the user-friendly qualities of the systems they are part of. Skill areas: **Foundation skills, science.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994.

3. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

Suggested Supplemental Resources

1. TPC Training Systems *Introduction to Air Conditioning and Refrigeration* is a 10-hour, 5-lesson program that starts with basics and moves all the way through air properties and psychrometrics.

2. Supplementary videos for TPC's "intro" series may be purchased separately as needed. These include two 4-tape series titled *Basic Air Conditioning.* The tapes cover all phases of heat measurement, the air conditioning cycle, handling AC instruments, and troubleshooting. For information about the probram or the video tapes, contact TPC Training Systems at 750 Lake Cook Road, Buffalo Grove, IL 60089, or you can call TPC toll-free at 1-800-837-8872.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

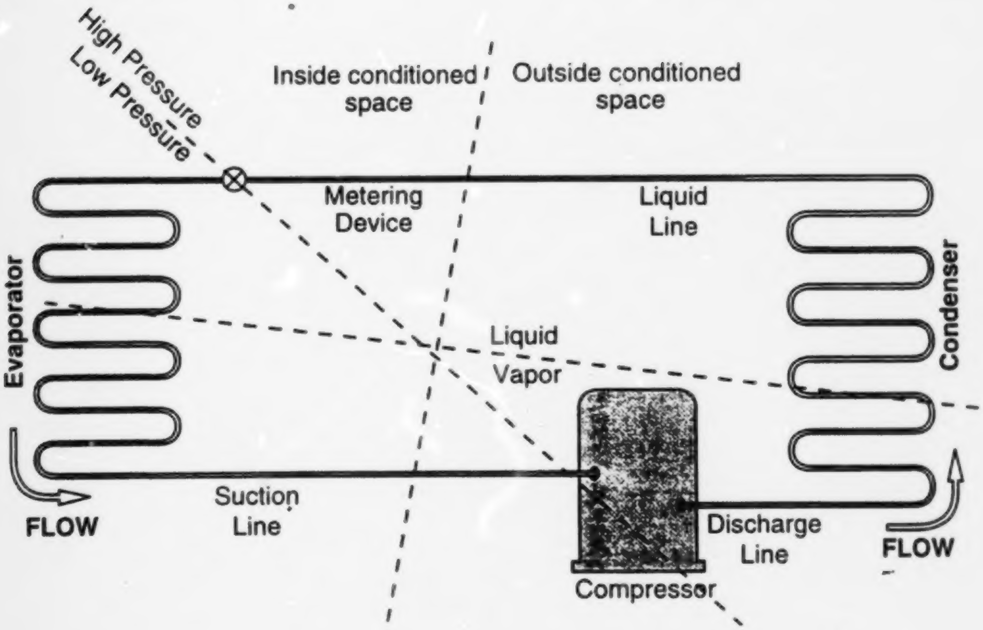
No—Is unable to perform job satisfactorily.

Basic Mechanical Refrigeration
Unit 11

Answers to Assignment Sheets

Assignment Sheet 1

a. Metering device
b. Liquid line
c. Condenser
d. Discharge line
e. Compressor
f. Suction line
g. Evaporator


High Pressure
Low Pressure
Inside conditioned space
Outside conditioned space
Metering Device
Liquid Line
Evaporator
Condenser
Liquid
Vapor
Suction Line
Discharge Line
Compressor
FLOW
FLOW

Assignment Sheet 2

a. (2)
b. (1) and (3)
c. (2) and (3)
d. (1) and (2)
e. (2) and (3)
f. (1)
g. (2)

Basic Mechanical Refrigeration
Unit 11

Answers to Written Test

1.
   - a. 9
   - b. 4
   - c. 5
   - d. 2
   - e. 10
   - f. 11
   - g. 8
   - h. 6
   - i. 3
   - j. 7
   - k. 1
2.
   - a. 3
   - b. 2
   - c. 6
   - d. 7
   - e. 4
   - f. 1
   - g. 5
3.
   - a. warm, cooler
   - b. mildly
   - c. suction
   - d. compressed into a smaller volume
   - e. pressure
   - f. cooler
   - g. liquid
   - h. high pressure, liquid
   - i. a pressure drop
   - j. system conditions
4. a, c, d, e, f
5.
   - a. rotating
   - b. "compliant"
   - c. "compliant"
   - d. paired augers
   - e. spin
6.
   - a. 4
   - b. 2
   - c. 1
   - d. 3
7.
   - a. 2
   - b. 5
   - c. 1
   - d. 3
   - e. 4
8.
   - a. 3
   - b. 2
   - c. 1
9.
   - a. (2)
   - b. (1)

Basic Mechanical Refrigeration
Unit 11

Written Test

Name ______________________________ Date ________________ Score ______

1. Match the terms on the right with their correct definitions.

_____a. Acids, sludge, solder, and corrosion that work their way into a system because of performance problems or improper service

_____b. A system sealed so that air or other environmental elements cannot enter it

_____c. A device installed at a point in a refrigeration system where it can be used by a technician to monitor the system

_____d. The addition or removal of heat that changes the state of a substance, but does not change its temperature or pressure

_____e. A device installed at a point in a refrigeration system where it can be used by a technician to service the system or stop or modify flow; it may or may not include a gauge port

_____f. A gauge port designed like the valve on an automobile tire so that it opens when pressure is applied and closes when pressure is withdrawn

_____g. Relating to the senses of sight, touch, smell, and taste

_____h. A point at which a liquid will change state if heat is added to or removed from it

_____i. The addition or removal of heat that changes the temperature of a substance

1. Superheat
2. Latent heat
3. Sensible heat
4. Closed system
5. Gauge port
6. Saturation
7. Subcooling
8. Sensory
9. Contaminants
10. Service valve
11. Schrader valve

Written Test

______ j. A temperature lower than the saturation temperature

______ k. A temperature higher than the saturation temperature

2. Match major refrigeration system components with their functions. Place the number beside the component in the blank beside the description of its function.

______ a. Performs the "refrigeration" functions of a system by changing liquid refrigerant into low-temperature, low-pressure superheated vapor

______ b. Carries low-temperature, low-pressure vapor to the compressor

______ c. Compresses low-temperature, low-pressure superheated vapor into high-temperature, high-pressure, superheated vapor

______ d. Carries superheated vapor from the compressor to the condenser

______ e. Performs the opposite of the evaporator; turns superheated gas back into a high-temperature, high-pressure liquid that is slightly subcooled

______ f. Carries subcooled, high-pressure liquid refrigerant to the metering device

______ g. Takes subcooled, high-pressure liquid from the condenser, changes it into a low-temperature, low-pressure saturated liquid which it feeds to the evaporator at a rate that matches the rate of evaporation

1. Liquid line
2. Suction line
3. Evaporator
4. Condenser
5. Metering device
6. Compressor
7. Discharge line

Written Test

3. Complete statements about how laws for thermodynamics and gases work in a refrigeration cycle. Circle the material that best completes each of the following statements.

    a. A basic law of thermodynamics says that heat moves from a (**warm**) (**cool**) to a (**cooler**) (**warmer**) space, and that is why heat from the warm air blown over the evaporator coils is absorbed by the cooler refrigerant passing through the coils.

    b. A basic law of gases states that when the temperature of a gas increases, the volume will increase proportionately, and that is why the refrigerant passing through the evaporator coils will reach its boiling point, change state by evaporation, and expand into a low-pressure (**mildly**) (**highly**) superheated gas.

    c. Because of the low-pressure of the gas leaving the evaporator, the compressor literally has to draw or suck the gas through the (**suction**) (**liquid**) line into the compressor.

    d. Another law of gases states that the relationship between volume and pressure is inverse, or the opposite, so that when the low-pressure vapor reaches the compressor, it is (**compressed into a smaller volume**) (**decompressed into a larger volume**) which turns it into a high-pressure vapor.

    e. Because of the high (**heat**) (**pressure**) of the vapor leaving the compressor, the gas literally pushes its way to the condenser.

    f. The law about heat flowing from a warmer to a cooler space functions again when the superheated vapor reaches the condenser because air blowing over the condenser is (**cooler**) (**warmer**) than the superheated vapor, so the vapor gives up heat to the air blowing over the condenser.

    g. In the condenser, the removal of heat from vaporized refrigerant causes the refrigerant to condense back into a (**liquid**) (**low pressure vapor**).

    h. The condenser removes enough heat to mildly cool or subcool the refrigerant, but enough (**high pressure**) (**heat**) remains to move the liquid refrigerant down the (**liquid**) (**suction**) line to the metering device.

    i. The metering device creates (**a pressure drop**) (**static pressure buildup**) that changes the incoming high-temperature, high-pressure subcooled liquid into a low-temperature, low-pressure liquid that is discharged to the evaporator so the refrigeration cycle can continue.

    j. In the following illustration, dotted lines indicate (**system conditions**) (**recommended placements**) such as points where refrigerant changes state and pressure, location of low and high side components, and what components are located inside and outside the conditioned space.

Written Test

4. Select true statements about reciprocating compressors and their applications. Place an "X" beside each true statement.

   ______a. Reciprocating compressors use a piston and cylinder to create mechanical compression and are classified as hermetic, semi-hermetic, or open.

   ______b. Hermetic compressors have a driving motor and compressor sealed in a housing that is welded together, but it can be internally repaired.

   ______c. Hermetic compressors are used for domestic refrigerators and freezers, for window air conditioners, and for central air conditioning systems.

   ______d. Semi-hermetic compressors have a driving motor and compressor together in a housing that is bolted together so that it can be disassembled for internal repair.

   ______e. Semi-hermetic compressors are used for central air conditioning systems of many different sizes and for light commercial refrigeration applications.

   ______f. Open compressors are also reciprocating compressors that have a crankshaft that extends through the housing so that the compressor can be powered by an outside motor and belt drive.

   ______g. Open compressors are used only in automotive air conditioning.

5. Complete statements about other compressor types and their applications. Circle the material that best completes each of the following statements.

   a. Rotary compressors are hermetic compressors, but instead of a piston and cylinder, they use (**rotating**) (**stationary**) blades or stationary vanes to develop compression; they are used in some air conditioning applications and in some low-temperature applications.

   b. Scroll compressors get their name because they have only two major parts, a stationary scroll and an orbiting scroll; scroll compressors are (**"compliant"**) (**"versatile"**) because they can adjust to handle liquid refrigerant or particulate matter, conditions that would damage other compressors.

   c. Because they have few parts to wear out and because of their (**"compliant"**) (**"versatile"**) performance characteristics, scroll compressors are popular in a wide range of ACR applications.

   d. Screw-type compressors have (**paired augers**) (**rotating blades**) that compress gas; they are used in industrial refrigeration systems that may manage 500 tons of refrigeration or more.

   e. Centrifugal compressors (**compress**) (**spin**) refrigerant and use centrifugal force to create pressure; centrifugal compressors may weigh several tons and are used in applications such as commercial chillers.

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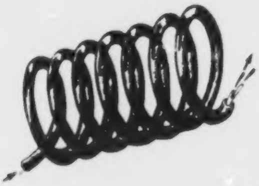
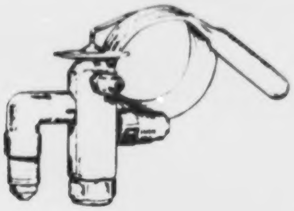
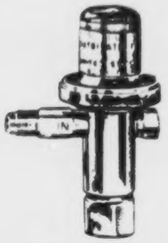
Written Test

6. Identify types of metering devices and their characteristics. Place the number beside the description of the device and its characteristics in the blank below its illustration.



a. ______________________ b. ______________________





c. ______________________ d. ______________________

1. This is a **thermostatic expansion valve**, a metering device operated by sensing temperature with a bulb installed on a suction line at the outlet of the evaporator.

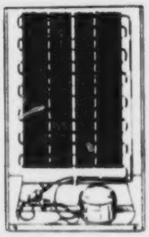
2. This is a **fixed orifice**, a simplistic refrigerant control with a small orifice that is easy to access and service; it can be an RFC type or a piston-type that can allow full reverse flow for heat pump applications.

3. This is an **automatic expansion valve**, a metering device that operates in response to evaporation pressure top maintain a constant pressure into the evaporator.

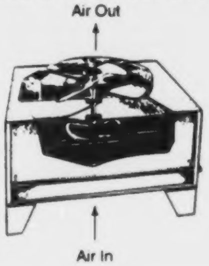
4. This is a **capillary tube**, a simplistic refrigerant control consisting of a short length of tubing or a coil of tubing with a small inside diamter.

Written Test

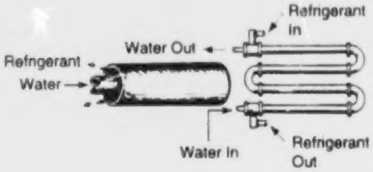
7. Identify types of condensers and their characteristics. Place the number beside the name of the condenser and its characteristics in the blank below its illustration.



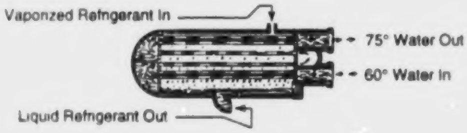
a. ______________________


Air Out
Air In

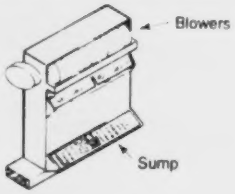
b. ______________________


Refrigerant In
Water Out
Refrigerant
Water
Water In
Refrigerant Out

c. ______________________


Vaporized Refrigerant In
75° Water Out
60° Water In
Liquid Refrigerant Out

d. ______________________


Blowers
Sump

e. ______________________

1. This is a **water-cooled tube-in-tube condenser** that transfers heat from refrigerant by use of an inner tube of circulating water with an outer tube circulating the refrigerant.

2. This is a **natural convection condenser** that transfers heat to surrounding air by means of natural air flow, sometimes called a static condenser.

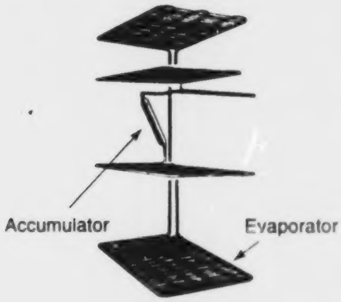
3. This is a **water-cooled shell-in-tube condenser** that transfers heat from refrigerant by use of a water-filled shell with a refrigerant tube passing through it.

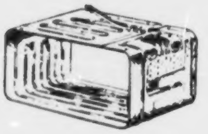
4. This is an **evaporative condenser**, a condenser style found on systems such as cooling towers where blowers are used to help remove heat and the cooled water is collected in a sump or catch basin at the bottom of the tower.

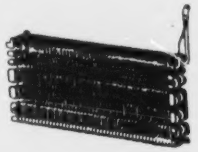
5. This is a **forced convection condenser** that transfers heat to surrounding air by using a fan or a blower.

Written Test

8. Identify types of evaporators and their characteristics. Place the number beside the definition of the evaporator and its characteristics in the blank below its illustration.







a. ______________ b. ______________ c. ______________

1. This is a **fin-type evaporator** that has fins surrounding the tubing through which refrigerant flows; they have a high rate of heat removal and this makes them popular for use with air conditioning systems.

2. This is a **shell-type evaporator** with coils to route refrigerant through the sides or sometimes along the back of a refrigerator; because they can be concealed from view, these evaporators are popular in both domestic and commercial refrigerators and freezers.

3. This is a **shelf-type evaporator** designed to let refrigerant flow through a series of coils formed to make shelves; shelf-type evaporators are use din both domestic and commercial refrigeration.

9. Solve problems about system design and sensory troubleshooting. Circle the number of the statement that best solves each of the following problems.

   a. You have to make a preliminary examination of an air conditioner, and you suspect the trouble may be in the evaporator. You left your manifold gauge set in the truck which is parked almost a block away. To save a walk back to the truck you could:

      (1) Check the discharge line out of the compressor; if it is cold to the touch, the evaporator is probably okay.

      (2) Check the suction line into the compressor; if it is cold to the touch, the evaporator is probably doing its job.

Written Test

b. You have to make a preliminary examination of an air conditioner, and you suspect the problem may be in the compressor, but you have no tools or gauges with you. Rather than drive back to the shop you could:

   (1) Check the discharge line out of the compressor; if it is too hot to touch, the compressor is probably doing its job.

   (2) Check the suction line into the compressor; if it is warm to the touch, the compressor is probably doing its job.

511

***Permission to duplicate this test is granted.**

Basic Mechanical Refrigeration
Unit 11

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Identify Components of a Basic Mechanical Refrigeration System Rating ______

Comments: ______________________

____

Assignment Sheet 2—Select Component Functions in a Basic Refrigeration Cycle Rating ______

Comments: ______________________

____

Job Sheet 1—Find and Identify Basic Refrigeration Rating ______

Comments: ______________________

____

Other ______________________

____

Written Tests: Pretest ______ Posttest ______

Total ______

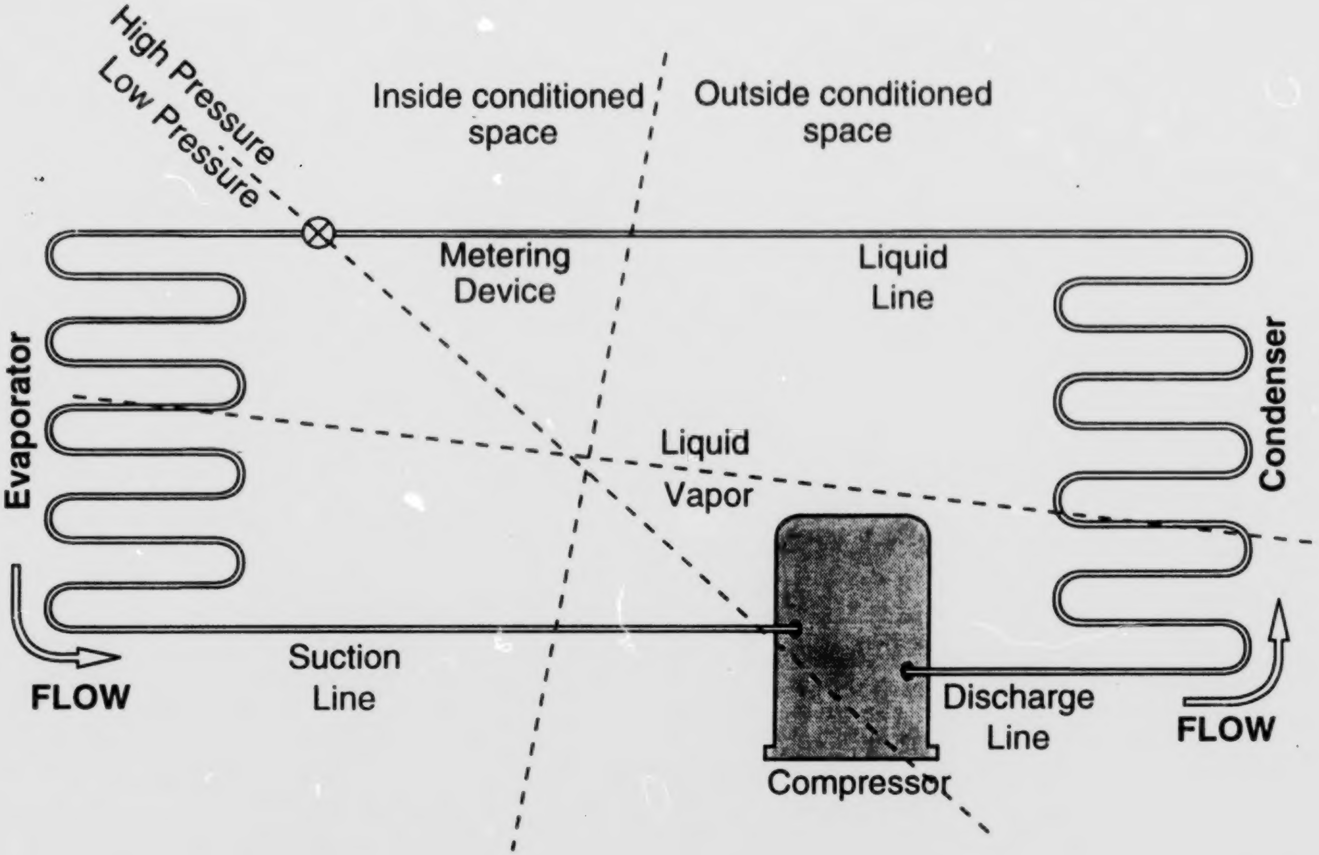
Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

512

*Permission to duplicate this form is granted.

Mechanical Refrigeration System



High Pressure
Low Pressure
Inside conditioned space
Outside conditioned space
Metering Device
Liquid Line
Evaporator
Condenser
Liquid
Vapor
Suction Line
Compressor
Discharge Line
FLOW
FLOW

513 514

Basic Mechanical Refrigeration
Unit 11

Information Sheet

1. **Terms and definitions**

   a. **Contaminants**— Acids, sludge, solder, and corrosion that work their way into a system because of performance problems or improper service

   b. **Closed system** — A system sealed so that air or other environmental elements cannot enter it

   c. **Gauge port (access valve)** — A device installed at a point in a refrigeration system where it can be used by a technician to monitor the system

   d. **Latent heat** — The addition or removal of heat that changes the state of a substance, but does not change its temperature or pressure

   e. **Service valve** — A device installed at a point in a refrigeration system where it can be used by a technician to service the system or stop or modify flow; it may or may not include a gauge port

   f. **Schrader valve** — A gauge port designed like the valve on an automobile tire so that it opens when pressure is applied and closes when pressure is withdrawn

   g. **Sensory** — Relating to the senses of sight, touch, smell, and taste

   h. **Saturation** — A point at which a liquid will change state if heat is added to or removed from it

   i. **Sensible heat** — The addition or removal of heat that changes the temperature of a substance

   j. **Subcooling** — A temperature lower than the saturation temperature

   k. **Superheat** — A temperature higher than the saturation temperature

2. **Major refrigeration system components and their functions**

   a. **Evaporator** — Performs the "refrigeration" functions of a system by changing liquid refrigerant into low-temperature, low-pressure superheated vapor

   b. **Suction line** — Carries low-temperature, low-pressure vapor to the compressor

Information Sheet

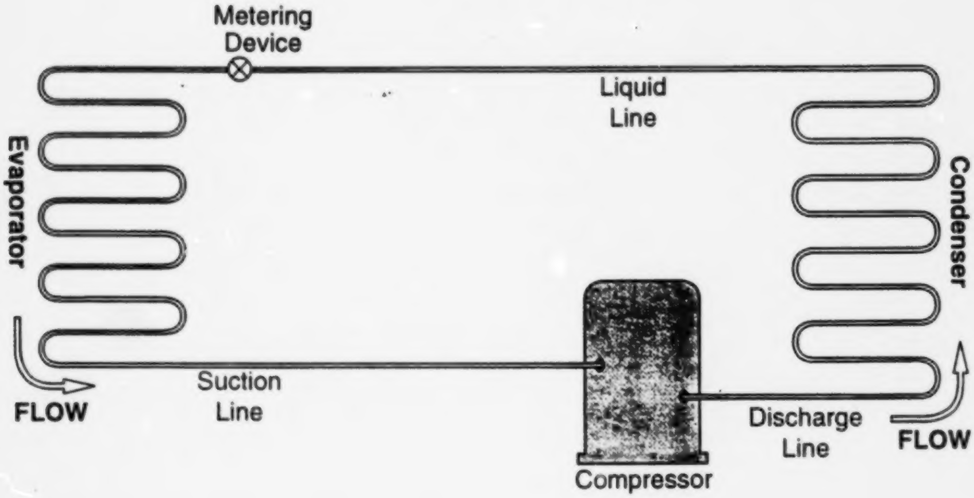
c. **Compressor** — Compresses low-temperature, low-pressure superheated vapor into high-temperature, high-pressure, superheated vapor

d. **Discharge line** — Carries superheated vapor from the compressor to the condenser

e. **Condenser**— Performs the opposite of the evaporator; turns superheated gas back into a high-temperature, high-pressure liquid that is slightly subcooled

f. **Liquid line** — Carries subcooled, high-pressure liquid refrigerant to the metering device

g. **Metering device** — Takes subcooled, high-pressure liquid from the condenser, changes it into a low-temperature, low-pressure saturated liquid which it feeds to the evaporator at a rate that matches the rate of evaporation



3. **How laws for thermodynamics and gases work in a refrigeration cycle**

a. A basic law of thermodynamics says that heat moves from a warm to a cooler space, and that is why heat from the warm air blown over the evaporator coils is absorbed by the cooler refrigerant passing through the coils.

b. A basic law of gases states that when the temperature of a gas increases, the volume will increase proportionately, and that is why the refrigerant passing through the evaporator coils will reach its boiling point, change state by evaporation, and expand into a low-pressure mildly superheated gas.

Information Sheet

c. Because of the low-pressure of the gas leaving the evaporator, the compressor literally has to draw or suck the gas through the suction line into the compressor.

d. Another law of gases states that the relationship between volume and pressure is inverse, or the opposite, so that when the low-pressure vapor reaches the compressor, it is compressed into a smaller volume which turns it into a high-pressure vapor.

e. Because of the high pressure of the vapor leaving the compressor, the gas literally pushes its way to the condenser.

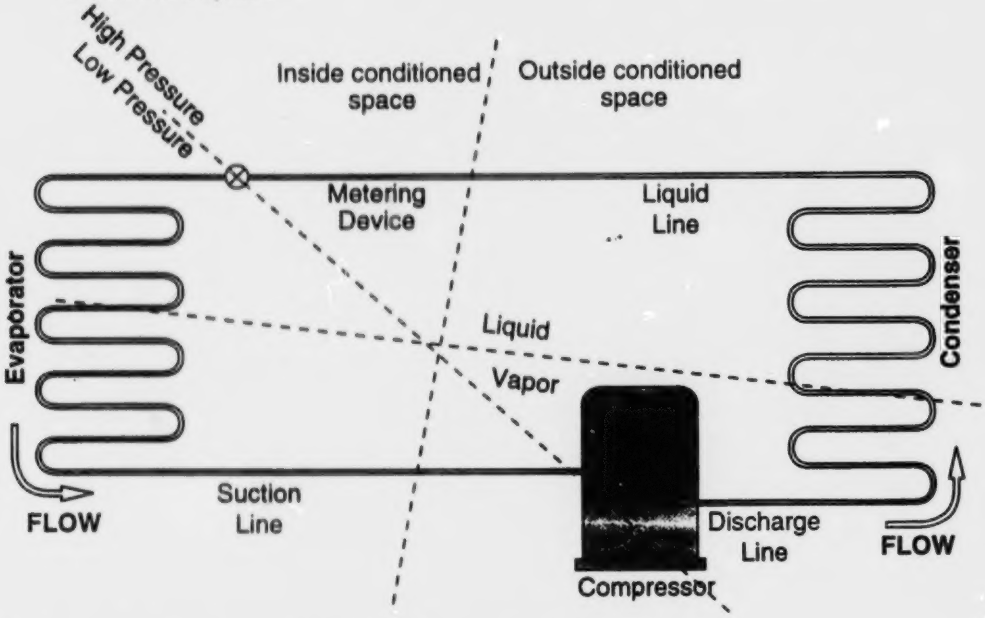
f. The law about heat flowing from a warmer to a cooler space functions again when the superheated vapor reaches the condenser because air blowing over the condenser is cooler than the superheated vapor, so the vapor gives up heat to the air blowing over the condenser.

g. In the condenser, the removal of heat from vaporized refrigerant causes the refrigerant to condense back into a liquid.

h. The condenser removes enough heat to mildly cool or subcool the refrigerant, but enough high pressure remains to move the liquid refrigerant down the liquid line to the metering device.

i. The metering device creates a pressure drop that changes the incoming high-temperature, high-pressure subcooled liquid into a low-temperature, low-pressure liquid that is discharged to the evaporator so the refrigeration cycle can continue.

j. In the following illustration, dotted lines indicate system conditions such as points where refrigerant changes state and pressure, location of low and high side components, and what components are located inside and outside the conditioned space.

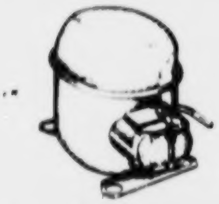

High Pressure
Low Pressure
Inside conditioned space
Outside conditioned space
Metering Device
Liquid Line
Evaporator
Condenser
Liquid
Vapor
FLOW
Suction Line
Discharge Line
FLOW
Compressor

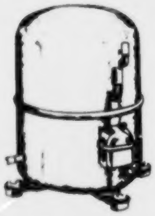
4. **Reciprocating compressors and their applications**

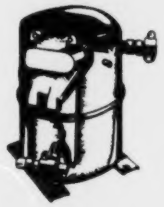
a. Reciprocating compressors use a piston and cylinder to create mechanical compression and are classified as hermetic, semi-hermetic, or open.

b. Hermetic compressors have a driving motor and compressor sealed in a housing that is welded together and cannot be internally repaired.

c. Hermetic compressors are used for domestic refrigerators and freezers, for window air conditioners, and for central air conditioning systems.


Domestic Refrigerators
and Freezers

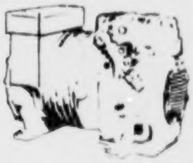

Window
Air Conditioners


Central
Air Conditioners

Information Sheet

d. Semi-hermetic compressors have a driving motor and compressor together in a housing that is bolted together so that it can be disassembled for internal repair.

e. Semi-hermetic compressors are used for central air conditioning systems of many different sizes and for light commercial refrigeration applications.

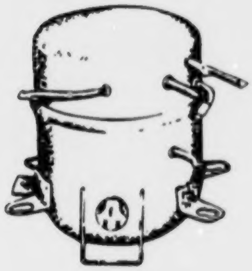


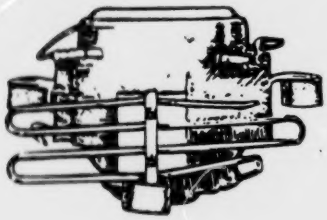
f. Open compressors are also reciprocating compressors that have a crankshaft that extends through the housing so that the compressor can be powered by an outside motor and belt drive.

g. Open compressors are used in automotive air conditioning and for some light commercial applications, especially supermarket freezers.

5. Other compressor types and their applications

a. Rotary compressors are hermetic compressors, but instead of a piston and cylinder, they use rotating blades or stationary vanes to develop compression; they are used in some air conditioning applications and in some low-temperature applications.

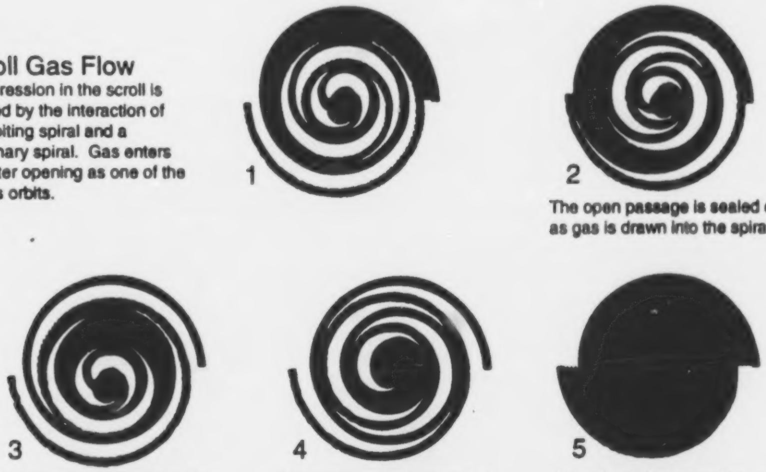




b. Scroll compressors get their name because they have only two major parts, a stationary scroll and an orbiting scroll; scroll compressors are "compliant" because they can adjust to handle liquid refrigerant or particulate matter, conditions that would damage other compressors.

Information Sheet

c. Because they have few parts to wear out and because of their "compliant" performance characteristics, scroll compressors are popular in a wide range of ACR applications.



Scroll Gas Flow
Compression in the scroll is created by the interaction of an orbiting spiral and a stationary spiral. Gas enters an outer opening as one of the spirals orbits.

The open passage is sealed off as gas is drawn into the spiral.

As the spiral continues to orbit, the gas is compressed into an increasingly smaller pocket.

By the time the gas arrives at the center port, discharge pressure has been reached.

Actually, during operation, all six gas passages are in various stages of compression at all times, resulting in nearly continuous suction and discharge.

Courtesy Copeland Corporation
Copeland is a registered trademark, and Compliant Scroll is a trademark of Copeland Corporation.

d. Screw-type compressors have paired augers that compress gas; they are used in industrial refrigeration systems that may manage 500 tons of refrigeration or more.

e. Centrifugal compressors spin refrigerant and use centrifugal force to create pressure; centrifugal compressors may weigh several tons and are used in applications such as commercial chillers.

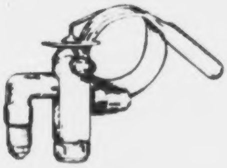
6. Types of metering devices and their characteristics

a. **Capillary tube** — A simplistic refrigerant control consisting of a short length of tubing or a coil of tubing with a small inside diameter

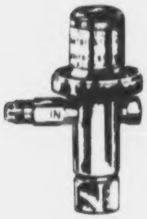
Information Sheet

b. **Fixed orifice** — A simplistic refrigerant control with a small orifice that is easy to access and service; in service it can be an RFC type or simple piston-type that can be reversed for heat pump applications

c. **Thermostatic expansion valve** — A metering device operated by sensing temperature with a bulb installed on the suction line at the outlet of the evaporator



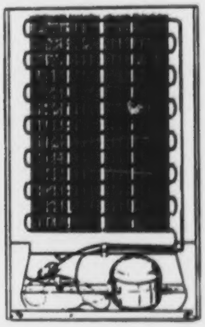
d. **Automatic expansion valve** — A metering device that operates in response to evaporator pressure to maintain a constant pressure into the evaporator



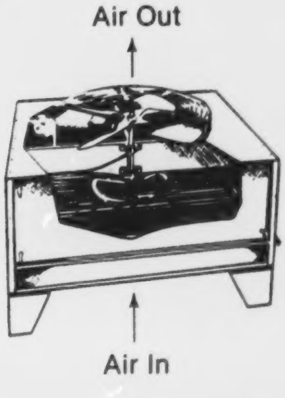
Information Sheet

7. **Types of condensers and their characteristics**

   a. **Natural convection condenser** — A condenser that transfers heat to surrounding air by means of natural air flow; sometimes called a static condenser

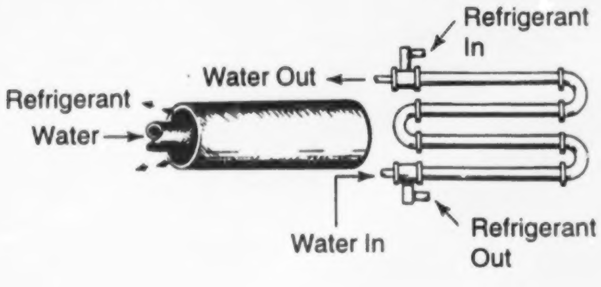


   b. **Forced convection condenser** — A condenser that transfers heat to surrounding air by using a fan or a blower

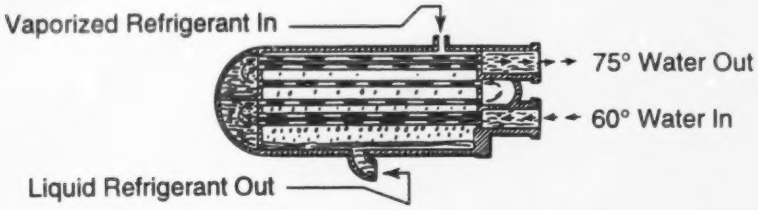


Information Sheet

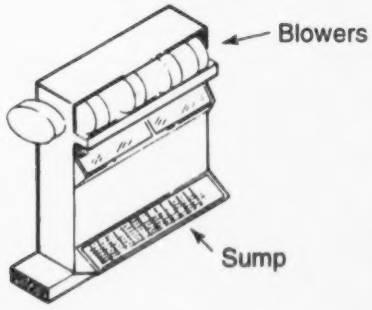
c. **Water-cooled tube-in-tube condenser** — A condenser that transfers heat from refrigerant by use of an inner tube of circulating water with an outer tube circulating the refrigerant


Refrigerant In
Water Out
Refrigerant
Water
Water In
Refrigerant Out

d. **Water-cooled shell-in-tube condenser** — A condenser that transfers heat from refrigerant by use of a water-filled shell with a refrigerant-filled tube passing through it


Vaporized Refrigerant In
75° Water Out
60° Water In
Liquid Refrigerant Out

e. **Evaporative condenser** — A condenser style found on systems such as cooling towers where blowers are used to help remove heat and the cooled water is collected in a sump or catch basin at the bottom of the tower

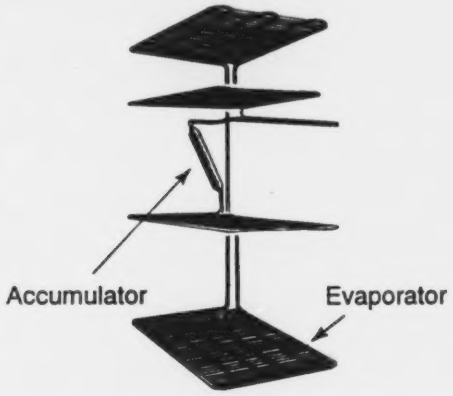

Blowers
Sump

Information Sheet

8. **Types of evaporators and their characteristics**

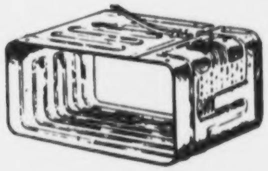
   a. Shelf-type evaporators are designed to let refrigerant flow through a series of coils formed to make shelves that can also be used to store products.

   b. Shelf-type evaporators are used in both domestic refrigerators and commercial refrigerators and freezers.



   c. Shell-type evaporators have coils designed to route refrigerant through the sides or sometimes along the back of a refrigerator or freezer.

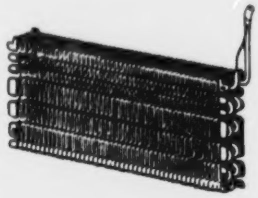
   d. Because they can be concealed from view and required minimal space, shell-type evaporators are popular in both domestic and commercial refrigerators and freezers.



   e. Fin-type evaporators have fins that surround the tubing through which refrigerant flows, and often accelerate heat removal with the addition of a fan.

Information Sheet

f. Their high rate of heat removal make fin-type evaporators popular with air conditioning systems.



g. Chiller evaporators are used to chill water for ACR applications, for drinking water, and for other purposes.

9. System design and sensory troubleshooting

a. System design not only dictates how a system will function, design dictates how a system should be maintained and serviced.

b. Vapor in the suction line is mildly superheated, but the suction line will feed cold to the touch; service technicians use this design feature as a quick check to see if the evaporator is doing its job.

Note: The temperature of the suction line is so low that the line to the compressor has to be insulated so condensation or ice will not form on it and cause dripping or ice buildup.

c. The temperature and pressure out of the evaporator provide the superheat measurement, another common reference point for service.

d. Temperature in the discharge line out of the compressor will be hot—too hot to hold with your hand, and service technicians use this design feature for a quick check to see if the compressor is doing its job.

e. The temperature and pressure in the liquid line at the condenser provide the subcooling measurement, another common reference point for service.

f. The temperature in the liquid line out of the condenser is warm, usually around 90°F, and service technicians use this design feature for a quick check to see if the condenser is doing its job.

g. Air or water temperatures entering and exiting the evaporator provide the measurements for temperature drop, and air or water temperatures entering and exiting the condenser provide measurements for temperature rise.

Information Sheet

h. You can see wires that have burned, you can smell a compressor that has burned out (and you'll never forget it), and generally speaking, sight, touch, and smell are all good troubleshooting tools to help isolate problems to general areas or specific components.

i. Good troubleshooting skills develop over time with exposure to systems of various sizes, but regardless of size, appreciation for system design promotes effective troubleshooting.

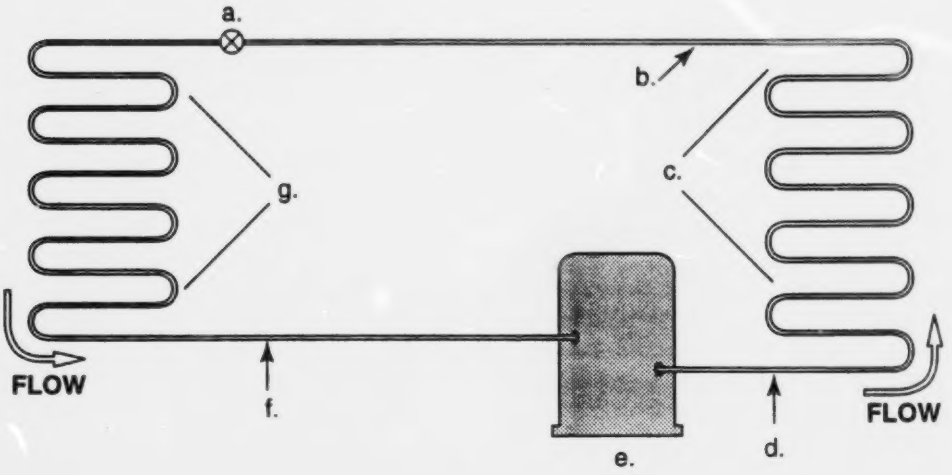
Basic Mechanical Refrigeration
Unit 11

Assignment Sheet 1—Identify Components of a Basic Mechanical Refrigeration System

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of identifications attempted	______
Number of identifications correct	______
System conditions properly marked off and identified	______

Directions: Examine the following graphic and insert the proper component name in the blank beside the letter that indicates its position in the system. Turn the page over and add dotted lines to properly indicate the conditions of the system in the illustration.

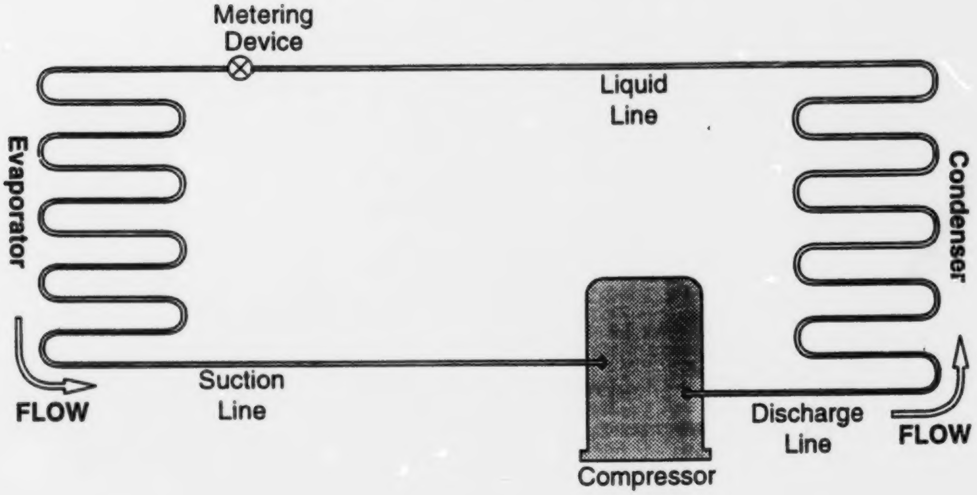


a. ________________ b. ________________ c. ________________

d. ________________ e. ________________ f. ________________

g. ________________

Assignment Sheet 1


Metering Device
Liquid Line
Evaporator
Condenser
FLOW
Suction Line
Compressor
Discharge Line
FLOW

Basic Mechanical Refrigeration
Unit 11

Assignment Sheet 2—Select Component Functions in a Basic Refrigeration Cycle

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of identifications attempted	______
Number of identifications correct	______
Percentage of correct answers	______

Directions: The following situations reflect component functions in a basic refrigeration cycle. Select the answer that best defines the component function. Note that more than one answer may be correct, so list all correct answers.

a. The compressor in a basic refrigeration cycle functions to:

   (1) Compress high-pressure vapor and discharge it as low-pressure vapor.

   (2) Compress low-pressure vapor and discharge it as high-temperature, high-pressure vapor.

   (3) Compress low-pressure vapor so that it becomes even lower pressure.

b. The condenser in a basic refrigeration cycle functions to:

   (1) Remove heat from the high-temperature vapor it receives from the compressor.

   (2) Cool superheated refrigerant through a process called evaporation.

   (3) Condense high-temperature vapor back into a liquid.

c. A metering device in a basic refrigeration cycle functions to:

   (1) Carry a combination of liquid/vapor refrigerant back to the evaporator.

   (2) Employ a pressure drop to lower pressure of liquid refrigerant and feed it to the evaporator.

   (3) Meter refrigerant into the evaporator so that it matches the rate of evaporation.

Assignment Sheet 2

d. The evaporator in a basic refrigeration cycle functions to:

  (1) Take heat from air blown over the evaporator coils to heat a liquid refrigerant until it boiled into a vapor.

  (2) Perform the "refrigerating" part of the refrigeration cycle.

  (3) Turn high-pressure liquid refrigerant into high-pressure vapor and discharge it through the suction line to the compressor.

e. The filter-drier in a liquid line functions to:

  (1) Slow the refrigerant down so it can continue to condense into a liquid at the metering device.

  (2) Remove contaminants from the refrigerant.

  (3) Remove traces of moisture that may be in the liquid line.

f. The accumulator in a basic refrigeration cycle functions to:

  (1) Collect discharge from the evaporator so that any liquid remaining in the discharge can be vaporized before it goes on to the compressor.

  (2) Collect discharge from the condenser so that any vapor remaining in the discharge can be condensed into liquid before it goes on to the metering device.

  (3) Help balance pressure between the two sides of a system.

g. The liquid receiver in a basic refrigeration cycle functions to:

  (1) Collect discharge from the condenser so that any liquid remaining in the discharge can be vaporized before it goes on to the metering device.

  (2) Collect discharge from the condenser so that any vapor remaining in the discharge can be condensed into liquid before it goes on to the metering device.

  (3) Help balance pressure between the two sides of a system.

Basic Mechanical Refrigeration
Unit 11

Job Sheet 1—Find and Identify Basic Refrigeration Components

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Compressor identification	______
Metering device identification	______
Condenser identification	______
Evaporator identification	______
Suction line identification	______
Liquid line identification	______
Discharge line identification	______

Directions: Your instructor has arranged for you to access a variety of refrigeration systems. Remove protective covers or panels as needed to find the basic components on each of the systems. When you are ready to identify the components n a given system, ask your instructor to evaluate your component identifications and check off those you complete properly. You must complete identifications for the following: A residential air conditioning system, a commercial refrigeration system, a domestic refrigerator or freezer, and a window air conditioner. Select tools as required to access systems.

Commercial Refrigeration Unit

1. Compressor ______
2. Metering device ______
3. Condenser ______
4. Evaporator ______
5. Suction line ______
6. Liquid line ______
7. Discharge line ______

Domestic Refrigerator or Freezer

1. Compressor ______
2. Metering device ______
3. Condenser ______
4. Evaporator ______
5. Suction line ______
6. Liquid line ______
7. Discharge line ______

Job Sheet 1

Residential Air Conditioning System

1. Compressor ______
2. Metering device ______
3. Condenser ______
4. Evaporator ______
5. Suction line ______
6. Liquid line ______
7. Discharge line ______

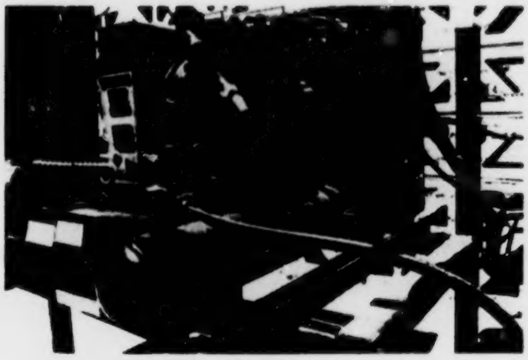
Window Air Conditioner

1. Compressor ______
2. Metering device ______
3. Condenser ______
4. Evaporator ______
5. Suction line ______
6. Liquid line ______
7. Discharge line ______

Evaluator's comments: ____

____

____



Refrigeration System Accessories
Unit 12

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify components of a mechanical refrigeration system with components, select functions for refrigeration system accessories, select operating positions for service valves, and find and identify refrigeration system accessories. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to refrigeration system accessories with their correct definitions.
2. Match refrigeration system accessories with their functions.
3. Complete statements about suction line accumulators and their applications.
4. Complete statements about oil separators and their applications.
5. Complete statements about noise and vibration control with large compressors.
6. Select true statements about filter-driers.
7. Solve problems about monitoring moisture and liquid in a system.
8. Match service valves with their operating characteristics.
9. Complete statements about guidelines for using service valves.
10. Solve problems about other refrigeration valves and their applications.
11. Select true statements about shut-off valves and their applications.

Objective Sheet

12. Identify components of a mechanical refrigeration system with accessories. (Assignment Sheet 1)
13. Select functions for refrigeration system accessories. (Assignment Sheet 2)
14. Select operating positions for service valves. (Assignment Sheet 3)
15. Find and identify refrigeration system accessories. (Job Sheet 1)

Refrigeration System Accessories
Unit 12

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add visual enhancement by making transparencies from materials that apply to the subject areas; make sure materials are copyright approved or your own products.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss and demonstrate the procedures in the assignment and job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Have a larger refrigeration system in operating condition available to physically show components as they are presented in Objectives 2 through 10. Skill areas: **learning skills, learning to learn.**

2. Use Objective 8 as an opportunity to demonstrate how to access a basic refrigeration system with a service valve and a manifold gauge set. Demonstrate how the king valve can be used to isolate refrigerant in a larger system. Skill areas: **Foundation skills, science and math.**

3. Select an industry in your area that has ACR equipment that may present configurations different from those shown in the unit. Divide the class into teams and arrange for students to visit the facility. Have each team report to the class about the basic components and accessories they find in the system(s). Skill areas: **Group effectiveness skills, teamwork.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

2. *Solenoid Valves*. Bulletin 30-10. St. Louis, MO: The Sporlan Valve Company, 1993.

3. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994.

4. *Valves and Accessories for Refrigeration and Air Conditioning Applications*. Catalog 111C. Melrose Park, IL: The Henry Valve Company, 1994.

5. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

Suggested Supplemental Resources

1. For information concerning many ACR accessories contact the Henry Valve Company. Write them at:

   The Henry Valve Company
   3215 North Avenue
   Melrose Park, IL 60160-1061

   Or call the Henry Valve Company at (708) 344-1100

2. For information concerning many ACR accessories, contact the Sporlan Valve Company. Write them at:

   The Sporlan Valve Company
   7525 Sussex Avenue
   St. Louis, MO 63143

   Or call the Sporlan Valve Company at (314) 647-2775

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Suggested Activities

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Refrigeration System Accessories
Unit 12

Answers to Assignment Sheets

Assignment Sheet 1

a. Liquid receiver
b. Liquid line service port
c. Filter/drier
d. Liquid line
e. Metering device
f. Evaporator
g. Suction line
h. Accumulator
i. Filter/drier
j. Compressor
k. Discharge line service port
l. Discharge line
m. Condenser

Assignment Sheet 2

a. (2)
b. (1)
c. (3)
d. (2)

Assignment Sheet 3

a. (1)
b. (2)
c. (3)

Refrigeration System Accessories
Unit 12

Answers to Written Test

1. a. 7
b. 6
c. 2
d. 8
e. 4
f. 11
g. 13
h. 14
i. 9
j. 10
k. 12
l. 15
m. 1
n. 5
o. 3

2. a. 3
b. 5
c. 1
d. 2
e. 4

3. a, d, e

4. a, c, d

5. a. threaten
b. compressor
c. sound-deadening baffles
d. parallel to
e. vibration shock

6. a. contaminants
b. desiccant
c. after
d. between
e. in
f. cores
g. a compressor burnout
h. acid

7. a. (2)
b. (1)

8. a. 3
b. 1
c. 2
d. 4

9. a, b, c, d, f

10. a. (1)
b. (2)

11. b, c

Refrigeration System Accessories
Unit 12

Written Test

Name ______________________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions. Definitions continue on next page.

_____a. The capacity of one substance to draw another substance into it like a sponge sucks up water

_____b. A gauge port added to a refrigerant system so that a gauge manifold can be connected to the system for monitoring or service

_____c. The tendency of gases or liquids to adhere in thin layers to solids with which they come in contact

_____d. The general disintegration of oil and refrigerant in a system brought on by moisture, dirt, acids, sludge, and varnish, usually in the presence of high operating temperatures

_____e. A drying agent used to absorb water and moisture

_____f. A device designed with a desiccant to trap moisture in a liquid or a gas flowing through a line

_____g. A device designed to remove particulate contaminants from a liquid or a gas flowing through a line

_____h. A device designed to trap particulate contaminants and excess moisture in refrigerant lines

1. Pressure stub/ process tube
2. Adsorption
3. Sludge
4. Desiccant
5. Service valve
6. Access valve
7. Absorption
8. Chemical breakdown
9. King valve
10. Manual shut-off valve
11. Drier
12. Particulate matter
13. Filter
14. Filter-drier
15. ppm

Written Test

______i. A shut-off valve located at the outlet of the liquid receiver in a refrigeration system so refrigerant can be trapped on the high side of the system for pump down

______j. A hand-operated valve located at a strategic position in a system so that a single component or specific area in a system can be serviced without interrupting system performance

______k. The very fine particles of scale, rust, metal, and solids in sludge that develop from extended system operation and especially from overheating

______l. The addition of 1 pound of a substance to 999,999 pounds of water so that the dissolved substance and water together weigh a million pounds

______m. A short piece of tubing attached to a refrigeration system to provide access for pressure readings

______n. A stem-type valve in a refrigeration system used for checking pressures and for system service

______o. The dark, heavy, viscous matter that forms when oil breaks down into organic acid and combines with carbons, metals, and other particulates in the system

Written Test

2. Match refrigeration system accessories with their functions. Place the number beside the component name in the blank beside the description of its function.

______a. Placed in the suction line just before the compressor to provide servicing and monitoring access to the low-pressure side of a system

______b. Placed in the liquid line just after the condenser to provide servicing and monitoring access to the high-pressure side of the system

______c. A cylinder placed at the output of the evaporator to collect evaporator discharge so that any liquid that may remain in the evaporator discharge can be turned into vapor before going on to the compressor through the suction line

______d. A basin placed at the output of the condenser to collect condenser discharge so that any vapor that may remain in the condenser discharge can be turned into liquid before going on to the metering device through the liquid line

______e. A device to trap moisture and other contaminants in a refrigeration system; placed between the liquid receiver and evaporator in the liquid line and sometimes placed between the accumulator and compressor in the suction line

1. Accumulator
2. Liquid receiver
3. Suction line service valve
4. Filter-drier
5. Liquid line service valve

3. Select true statements about suction line accumulators and their functions. Place an "X" beside each true statement.

______a. In ideal situations, no liquid comes out of the evaporator, but in reality, liquid refrigerant is sometimes ejected from the evaporator along with oil.

______b. Since a compressor is designed to compress only liquid, vapor refrigerant can damage compressor reed valves, pistons, rods, and crank shafts.

______c. An accumulator is installed just before the evaporator in the suction line so that it can pick up any liquid in the suction line, vaporize it, and send it on to the compressor.

Written Test

______d. The accumulator also traps any oil in the suction line and meters it back in appropriate quantities to the compressor.

______e. Although horizontal accumulators are in use, vertical accumulators are the most common, and they are usually sized with a holding capacity equal to 50 percent of the system charge, but small enough not to add excessive pressure drop tot he system.

4. Select true statements about oil separators and their functions. Place an "X" beside each true statement.

______a. Some oil will almost always leave the compressor crank case and be discharged out of the compressor along with refrigerant.

______b. The main function of an oil separator is to separate the oil from the refrigerant and return it to the accumulator before it can enter other components of the system.

______c. Oil separators are in common use on small systems, and they are frequent components of low temperature refrigeration units and larger air conditioning systems.

______d. On systems large enough to demand sophisticated oil control systems, an oil separator may be used in conjunction with an oil reservoir and oil level regulators.

5. Complete statements about noise and vibration control with large compressors. Circle the material that best completes each of the following statements.

a. The larger compressors in larger refrigeration systems pose special problems with noise which can be loud enough to discomfort people, and vibration which can be strong enough to (**threaten**) (**destroy**) system components.

b. To "dampen" or control noise, larger systems have mufflers installed right after the (**compressor**) (**service port**) in the discharge line.

c. Most mufflers route compressor discharge into lines that change it directionally as it passes through (**sound-deadening baffles**) (**special tubing**).

d. To minimize vibration, larger systems have a vibration eliminator installed in the discharge line (**parallel to**) (**in line with**) the crankshaft of the compressor.

e. A vibration eliminator is designed to absorb and distribute (**vibration shock**) (**sound waves**) along a length of wafer-like baffles; the vibration eliminator also muffles sound from a compressor.

Written Test

6. Complete statements about filter-driers and their applications. Circle the material that best completes each of the following statements.

   a. Filter-driers, as the name implies, perform the dual roles of filtering (**contaminants**) (**dirt**) and drying out moisture from a system.

   b. To accomplish their purposes, filter-driers contain a (**desiccant**) (**filter**) which absorbs moisture that passes through it, and other material that acts as a magnet to absorb particulate contaminants that pass over it.

   c. A filter-drier is usually placed in the liquid line right (**before**) (**after**) the receiver, and can be installed with flare nuts or sweated in.

   d. Filter-driers designed especially for capillary tube metering devices are sweated or brazed into the line (**between**) (**after**) the capillary tube and the evaporator.

   e. Filter-driers are directionally orientated and should be installed so that the marking arrow on the case points (**in**) (**opposite**) the direction of flow, or the "in" "out" ends of the filter-drier are properly oriented.

   f. Some filter-driers have replaceable (**cores**) (**cases**) so that the filtering element can be changed as specified by the manufacturer or as system operation demands.

   g. Filters are recommended to be permanently installed on the suction line just before the compressor prior to system start up, and on the suction line of a system that has been cleaned up after (**a compressor burnout**) (**retrofitting**).

   h. Replaceable filters for recycling machines require cores with high moisture absorption and (**acid**) (**water**) removal capacities; this increased capacity is achieved with special desiccant materials.

Written Test

7. Solve problems about monitoring moisture and liquids in a system. Circle the number of the statement that best solves each of the following problems.

   a. A coworker has been asked to make a quick check of the refrigerant level in a system. The worker knows that a liquid indicator will provide the information, but can't find the indicator. To solve the problem, you could:

      (1) Stop what you're doing and help your coworker find the indicator.

      (2) Remind your friend that the indicator should be installed in the liquid line just after the receiver or filter-drier.

   b. A coworker has been asked to make a quick check of the amount of moisture in a system. The worker knows where the liquid indicator for monitoring refrigerant is located, but is not quite sure how to check the moisture content. To help solve the problem, you could:

      (1) Remind your friend that the sight glass for monitoring refrigerant level also contains a moisture indicator that can be evaluated by referencing a color code.

      (2) Remind your friend that moisture is measured in parts per million and that it will require a special instrument for measurement.

8. Match service valves and their operating positions with their functions. Place the number beside the valve or position in the blank beside the description of its characteristics. Descriptions continue on next page.

______a. Stem-type valves usually located for the convenience of monitoring or servicing the compressor or the liquid receiver

______b. A service valve with the stem turned counterclockwise all the way out, the normal operating position of a service valve so that vapor or refrigerant will continue to pass into the component

______c. A service valve with the stem turned clockwise a couple of turns to permit vapor or liquid refrigerant to continue to pass into the component and into the service port where it can be monitored

1. Backseated
2. Cracked
3. Service valves
4. Frontseated

Written Test

______d. A service valve with the stem turned clockwise all the way in so that it shuts off the supply of vapor to the compressor or liquid refrigerant to the receiver, but still allows vapor or liquid into the service port where it can be monitored

9. Select true statements about service valves and their applications. Place an "X" beside each true statement.

______a. When a service valve is backseated and the system is operating normally, the cap nut on the service port can be safely removed so the center hose from the manifold gauge set can be connected to the service port.

______b. A suction line service valve is usually permanently installed into the compressor and the suction line is connected into it.

______c. A discharge line service valve is usually permanently installed into the compressor and the discharge line is connected into it.

______d. A service valve is usually permanently installed into the liquid receiver on the filter-drier side of the receiver and the liquid line is connected into it.

______e. The service valve after the receiver is commonly called a "system valve" because it can be closed to permit pump down of the system, and in that sense, it can rule the system.

______f. A service valve is sometimes installed into the liquid receiver on the evaporator side of the receiver so it can be used with the other liquid receiver service valve to isolate the refrigerant in a system.

10. Solve problems about other common refrigeration valves and their applications. Circle the number in front of the statement that best solves each of the following problems.

a. A coworker is looking for a way to access a system that has had no access valve installed at the factory. The worker seems to be at a loss about where to start and what to do. You can help solve the problem if you:

(1) Remind your coworker to find the pig tail that comes out of the compressor and install a schrader valve on it.

(2) Have the coworker shut the system down and disconnect a fitting so entry can be made to the system.

Written Test

b. A coworker has just finished servicing a system that required the temporary installation of a saddle valve. The worker is delighted that the job didn't last long and picks up tools preparing to leave the job site. You can help your coworker solve a problem if you:

(1) Tell your friend to double check everything before quitting.

(2) Remind your friend that saddle valves are temporary installations because they will eventually leak, and suggest that a schrader valve be installed for permanent use.

11. Select true statements about shut-off valves and their applications. Place an "X" beside each true statement.

______a. Shut-off valves are stem-type valves that are always hand operated for quick shut-down.

______b. Shut-off valves are located at strategic places in a refrigeration system to permit the isolation of single components or selected sections of the system for monitoring, service, or repair.

______c. Shut-off valves help eliminate the need for accessing a system at a point that might permit refrigerant to be expelled into the atmosphere or where air might enter into a system.

*Permission to duplicate this test is granted.

Refrigeration System Accessories
Unit 12

Unit Evaluation Form

Student Name ________________________ Unit Rating __________

Assignment Sheet 1—Identify Components of a Mechanical Refrigeration System With Accessories Rating ______

Comments: ________________________

____

Assignment Sheet 2—Select Functions for Refrigeration System Accessories Rating ______

Comments: ________________________

____

Assignment Sheet 3—Select Operating Positions for Service Valves Rating ______

Comments: ________________________

____

Job Sheet 1—Find and Identify Refrigeration System Accessories Rating ______

Comments: ________________________

____

Other ________________________

____

Unit Evaluation Form

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ________________________________ Date ____________

Student Signature ________________________________ Date ____________

5.10

*Permission to duplicate this form is granted.

Refrigeration System Accessories
Unit 12

Information Sheet

1. **Terms and definitions**

   a. **Absorption** — The capacity of one substance to draw another substance into it like a sponge sucks up water

   b. **Access valve** — A gauge port added to a refrigerant system so that a gauge manifold can be connected to the system for monitoring or service

   c. **Adsorption** — The tendency of gases or liquids to adhere in thin layers to solids with which they come in contact

   d. **Chemical breakdown** — The general disintegration of oil and refrigerant in a system brought on by moisture, dirt, acids, sludge, and varnish, usually in the presence of high operating temperatures

   e. **Desiccant** — A drying agent used to absorb water and moisture

   f. **Drier** — A device designed with a desiccant to trap moisture in a liquid or a gas flowing through a line

   g. **Filter** — A device designed to remove particulate contaminants from a liquid or a gas flowing through a line

   h. **Filter-drier** — A device designed to trap particulate contaminants and excess moisture in refrigerant lines

   i. **King valve** — A shut-off valve located at the outlet of the liquid receiver in a refrigeration system so refrigerant can be trapped on the high side of the system for pump down

   j. **Manual shut-off valve** — A hand-operated valve located at a strategic position in a system so that a single component or specific area in a system can be serviced without interrupting system performance

   k. **Particulate matter** — The very fine particles of scale, rust, metal, and solids in sludge that develop from extended system operation and especially from overheating

   l. **ppm (parts per million)** — The addition of 1 pound of a substance to 999,999 pounds of water so that the dissolved substance and water together weigh a million pounds

Information Sheet

m. **Pressure stub/process tube** — A short piece of tubing attached to a refrigeration system to provide access for pressure readings

n. **Service valve** — A stem-type valve in a refrigeration system used for checking pressures and for system service

o. **Sludge** — The dark, heavy, viscous matter that forms when oil breaks down into organic acid and combines with carbons, metals, and other particulates in the system

2. **Refrigeration system accessories and their functions**

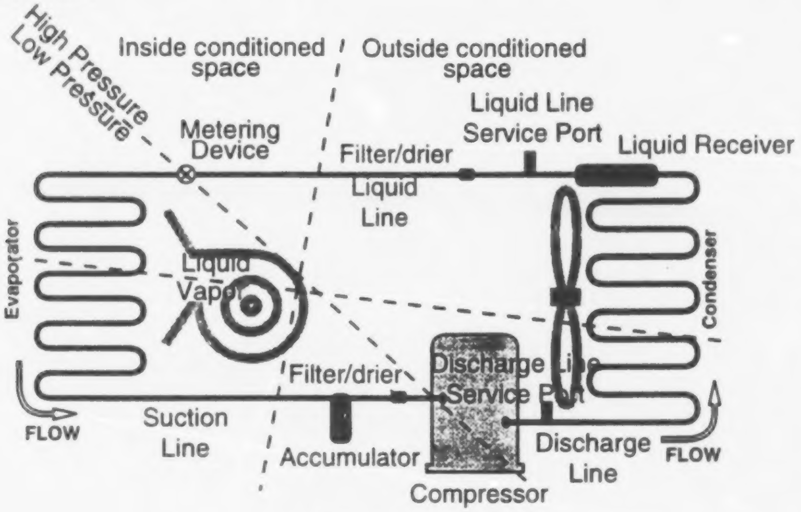
a. **Suction line service valve** — Placed in the suction line just before the compressor to provide servicing and monitoring access to the low-pressure side of a system

b. **Liquid line service valve** — Placed in the liquid line just after the condenser to provide servicing and monitoring access to the high-pressure side of the system

c. **Accumulator** — A cylinder placed at the output of the evaporator to collect evaporator discharge so that any liquid that may remain in the evaporator discharge can be turned into vapor before going on to the compressor through the suction line.

d. **Liquid receiver** —A basin placed at the output of the condenser to collect condenser discharge so that any vapor that may remain in the condenser discharge can be turned into liquid before oging on to the metering device through the liquid line

e. **Filter-drier** — A device to trap moisture and other contaminants in a refrigeration system; placed between the liquid receiver and evaporator in the liquid line and sometimes placed between the accumulator and compressor in the suction line


High Pressure
Low Pressure
Inside conditioned space
Outside conditioned space
Liquid Line Service Port
Metering Device
Filter/drier
Liquid Receiver
Liquid Line
Evaporator
Liquid
Vapor
Condenser
Filter/drier
Discharge Line Service Port
FLOW
Suction Line
Accumulator
Discharge Line
FLOW
Compressor

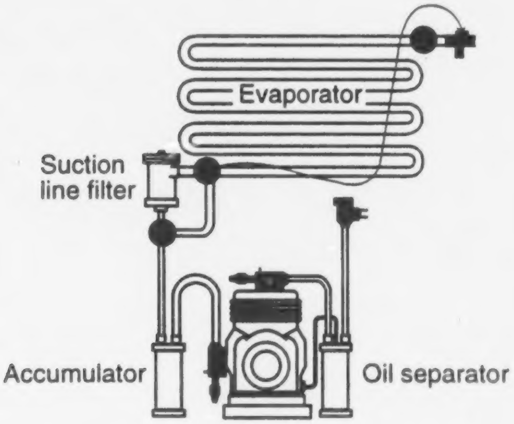
Information Sheet

3. Suction line accumulators and their functions

a. In ideal situations, no liquid comes out of the evaporator, but in reality, liquid refrigerant is sometimes ejected from the evaporator along with oil.

b. Since a compressor is designed to compress only vapor, liquid refrigerant can damage compressor reed valves, pistons, rods, and crank shafts.

c. An accumulator is installed just after the evaporator in the suction line so that it can pick up any liquid in the suction line, vaporize it, and send it on to the compressor.



Courtesy Henry Valve Company

d. The accumulator may also trap any oil in the suction line and meters it back in appropriate quantities to the compressor.

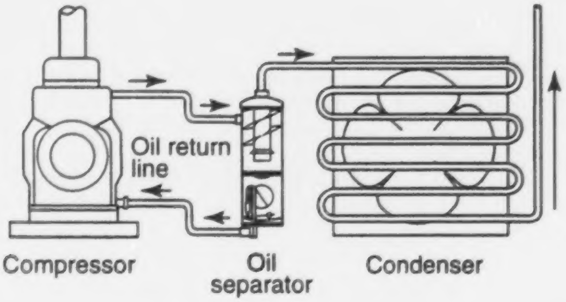
e. Although horizontal accumulators are in use, vertical accumulators are the most common, and they are usually sized with a holding capacity equal to 50 percent of the system charge, but small enough not to add excessive pressure drop to the system.

Information Sheet

4. Oil separators and their functions

a. Some oil will almost always leave the compressor crank case and be discharged out of the compressor along with refrigerant.

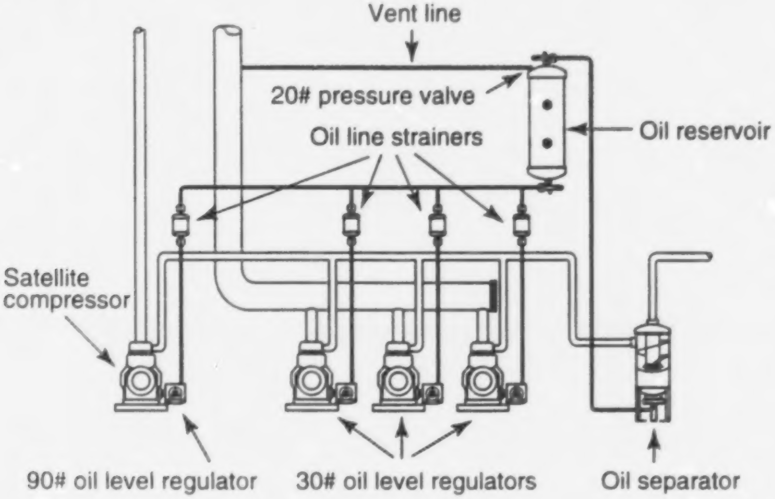
b. The main function of an oil separator is to separate the oil from the refrigerant and return it to the compressor crankcase before it can enter other components of the system.


Oil return line
Compressor
Oil separator
Condenser

Courtesy Henry Valve Company

c. Oil separators are in common use on small systems, and they are frequent components of low temperature refrigeration units and larger air conditioning systems.

d. On systems large enough to demand sophisticated oil control systems, an oil separator may be used in conjunction with an oil reservoir and oil level regulators.


Vent line
20# pressure valve
Oil line strainers
Oil reservoir
Satellite compressor
90# oil level regulator
30# oil level regulators
Oil separator

Courtesy Henry Valve Company

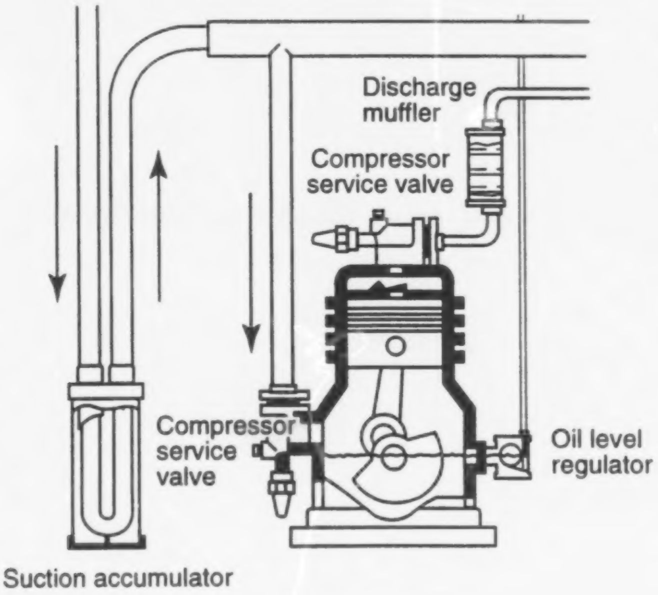
Information Sheet

5. Noise and vibration control with large compressors

a. The larger compressors in larger refrigeration systems pose special problems with noise which can be loud enough to discomfort people, and vibration which can be strong enough to threaten system components.

b. To "dampen" or control noise, larger systems have mufflers installed right after the compressor in the discharge line.

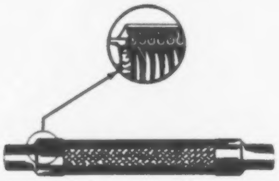
c. Most mufflers route compressor discharge into lines that change it directionally as it passes through sound-deadening baffles.


Discharge muffler
Compressor service valve
Compressor service valve
Oil level regulator
Suction accumulator

Courtesy Henry Valve Company

d. To minimize vibration, larger systems have a vibration eliminator installed in the discharge line parallel to the crankshaft of the compressor.

e. A vibration eliminator is designed to absorb and distribute vibration shock along a length of wafer-like baffles; the vibration eliminator also muffles sound from a compressor.



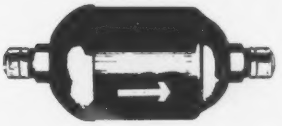
Information Sheet

6. Filter-driers and their applications

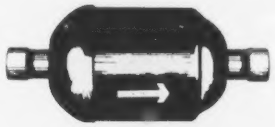
a. Filter-driers, as the name implies, perform the dual roles of filtering contaminants and drying out moisture from a system.

b. To accomplish their purposes, filter-driers contain a desiccant which absorbs moisture that passes through it, and other material that acts as a magnet to absorb particulate contaminants that pass over it.

c. A filter-drier is usually placed in the liquid line right after the receiver, and can be installed with flare nuts or sweated in.

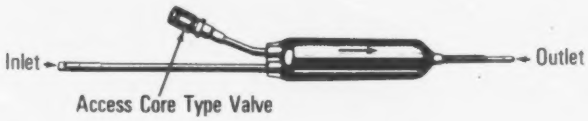


Flare

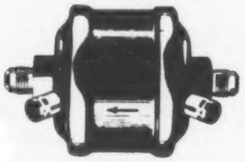


Sweat

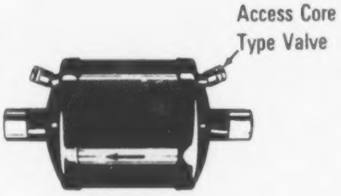
d. Filter-driers designed especially for capillary tube metering devices are sweated or brazed into the line between the capillary tube and the evaporator.



e. Filter-driers are directionally orientated and should be installed so that the marking arrow on the case points in the direction of flow, or the "in" "out" ends of the filter-drier are properly oriented.



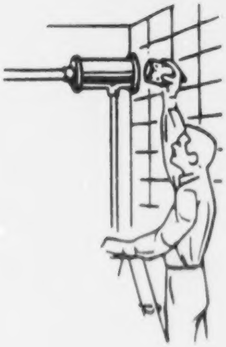
Flare



Sweat

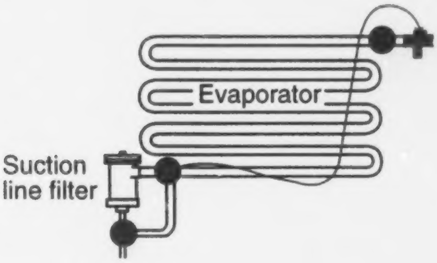
Information Sheet

f. Some filter-driers have replaceable cores so that the filtering element can be changed as specified by the manufacturer or as system operation demands.



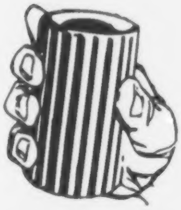
Courtesy Henry Valve Company

g. Filters are recommended to be permanently installed on the suction line just before the compressor prior to system start up, and on the suction line of a system that has been cleaned up after a compressor burnout.



Courtesy Henry Valve Company

h. Replaceable filters for recycling machines require cores with high moisture absorption and acid removal capacities; this increased capacity is achieved with special desiccant materials.



Courtesy Henry Valve Company

Information Sheet

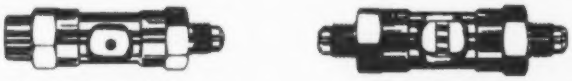
7. Monitoring moisture and liquids in a system

a. A major part of refrigeration system design is the amount of refrigerant charge the system needs for proper operation.

b. In smaller systems like domestic refrigerators, the amount of refrigerant charge needs to be exact or very close to it, and in some systems, total refrigerant demand may vary with load conditions and the liquid receiver is sized to handle enough refrigerant to handle system load variations.

c. A liquid indicator installed in the liquid line just after the receiver or filter-drier (or both) indicates the amount of refrigerant in the system and can alert a technician to a refrigerant level too low or too high.

Flare Type



Female to Male

Male to Male

Sweat Type

d. A moisture indicator is installed much like a liquid indicator, but it measures the amount of moisture in the refrigerant, not the amount of refrigerant in a system.

e. The safe moisture level varies with the refrigerant, and is expressed in parts per million:

   (1) Moisture limit for R-12 is 15 ppm.

   (2) Moisture limit for R-22 is 60 ppm.

   (3) Moisture limit for R-502 is 30 ppm.

f. Sight glasses may monitor both liquid charge and moisture content, and provide a color-coded scale for visual evaluation.

Information Sheet

g. Follow manufacturer's guidelines for installing and reading a sight glass; a typical color-coded scale is presented in the following graphic.

MOISTURE CONTENT PPM

See All Shows	Liquid Line Temp.	Refrigerants 11 & 12			Refrigerant 22			Refrigerants 502, 113 & 114			Refrigerant 500		
		75°	**100°**	125°	75°	**100°**	125°	75°	**100°**	125°	75°	**100°**	125°
Green DRY		Below 5	Below **10**	Below 20	Below 30	Below **45**	Below 60	Below 10	Below **20**	Below 30	Below 40	Below **60**	Below 100
Chartreuse CAUTION		5-15	**10-30**	20-50	30-90	**45-130**	60-180	10-45	**20-65**	30-110	40-90	**60-150**	100-230
Yellow WET		Above 15	Above **30**	Above 50	Above 90	Above **130**	Above 180	Above 45	Above **65**	Above 110	Above 90	Above **150**	Above 230

BOLD figures are for the average design conditions of refrigerant liquid lines operating at 100°F. Since the actual temperature is not critical, a satisfactory estimate can be made by comparing it to body temperature. If it feels cool to the touch, use 75°F., whereas if it feels warm, use 125°F. column figures. The See-All calibration information given above is based on detailed experimental data for Refrigerants 12, 22, 500, 502, and 113. The calibration information on other refrigerants and solvents was obtained from a comparison of their properties with 12, 22, 500, 502, and 113. For the less common liquids the following moisture calibration is suggested.

Refrigerant 21 ...... use ...... "22" calibration
Refrigerant 30 ...... use ...... "22" calibration
Trichloroethylene ...... use ...... "22" calibration
Perchloroethylene ...... use ...... "113" calibration
Ammonia .... See-All Not Suitable

FOR AIR — Tests on air show that the See-All changes color in the range of **0.5% to 2.0% R.H.** In ordinary air lines this means that the See-All will change color at dew points in the range of minus 40° to minus 60°F.

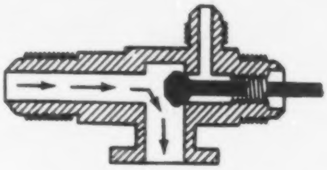
© 1992 by Sporlan Valve Company. Reprinted with permission.

h. The moisture-detecting element in a sight glass may require replacement because of exposure to excess moisture or acid, and replacement elements or removable cartridges are used for a quick change out.

8. Service valves, their operating positions and functions

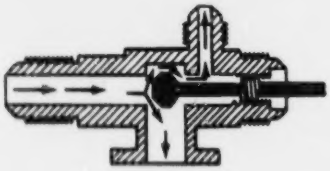
a. **Service valves** — Stem-type valves usually located for the convenience of monitoring or servicing the compressor or the liquid receiver

b. **Backseated** — A service valve with the stem turned counterclockwise all the way out, the normal operating position of a service valve so that vapor or refrigerant will continue to pass into the component

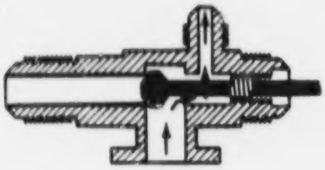


Information Sheet

c. **Cracked**— A service valve with the stem turned clockwise a couple of turns to permit vapor or liquid refrigerant to continue to pass into the component and into the service port where it can be monitored

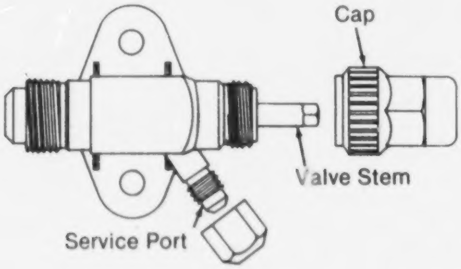


d. **Frontseated** — A service valve with the stem turned clockwise all the way in so that it shuts off the supply of vapor to the compressor or liquid refrigerant to the receiver, but still allows vapor or liquid into the service port where it can be monitored



9. **Service valves and their applications**

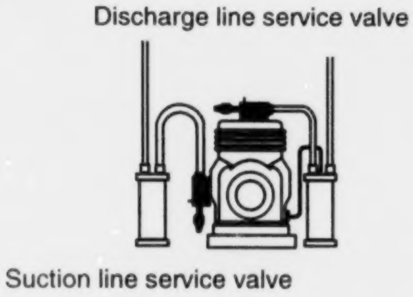
   a. When a service valve is backseated and the system is operating normally, the cap nut on the service port can be safely removed so the center hose from the manifold gauge set can be connected to the service port.



   b. A suction line service valve is usually permanently installed into the compressor and the suction line is connected into it.

Information Sheet

c. A discharge line service valve is usually permanently installed into the compressor and the discharge line is connected into it.

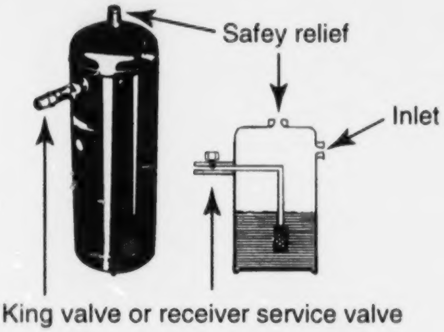

Discharge line service valve
Suction line service valve

Courtesy Henry Valve Company

d. A service valve is usually permanently installed into the liquid receiver on the filter-drier side of the receiver and the liquid line is connected into it.

e. The service valve after the receiver is commonly called a "king valve" because it can be closed to permit pump down of the system, and in that sense, it can rule the system.

f. A service valve is sometimes installed into the liquid receiver on the evaporator side of the receiver so it can be used with the other liquid receiver service valve to isolate the refrigerant in a system.

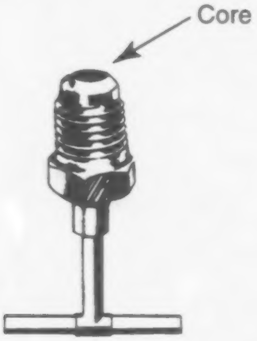

Safey relief
Inlet
King valve or receiver service valve

10. **Other common refrigeration valves and their applications**

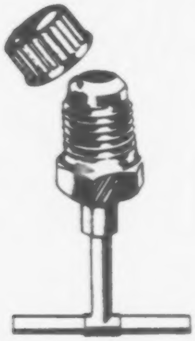
a. Schrader valves have a valve core just like the valve core on an automobile tube or tire; when the core is depressed, pressure can pass through the valve, and when the core is released, the valve is closed.

Information Sheet

b. Schrader valves are almost always permanently brazed into a line to provide access at points where access valves were not installed by the manufacturer, and in domestic system, schrader valves are placed on the pig tail that comes out of the compressor.

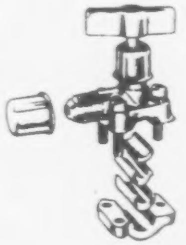


c. Schrader valves have cap nuts to protect them until the valve needs to be accessed.



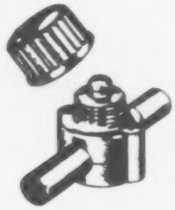
d. Saddle valves, also called "clamp on" valves are used only for servicing domestic refrigerators and freezers.

e. Saddle valves get their name from the way they saddle the refrigerant line and then are clamped into place so a sharp steel pin can be screwed into the line to puncture it.



Information Sheet

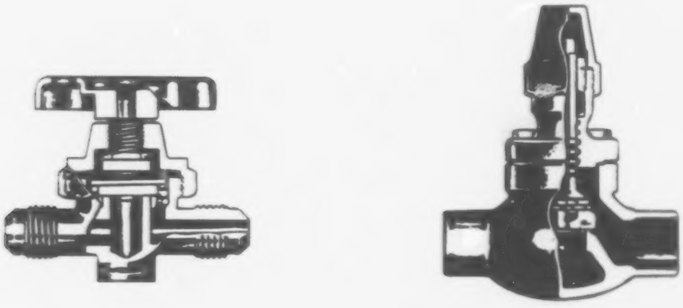
f. Saddle valves have a service port with a cap nut to protect the port until the valve needs to be accessed.



g. Saddle valves should always be considered temporary because, in time, they will leak, and that is why they should always be replaced with a schrader valve after service is complete.

11. Shut-off valves and their applications

a. Shut-off valves are stem-type valves that may be controlled with a ratchet wrench or hand operated.



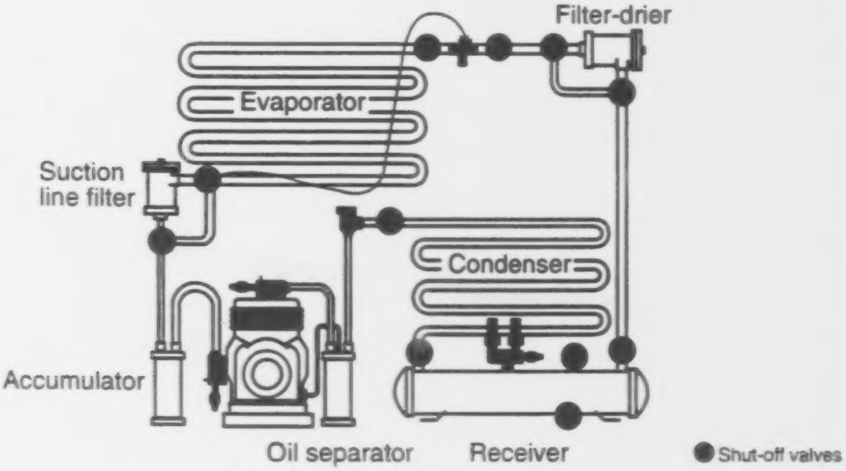
Courtesy Henry Valve Company

b. Shut-off valves are located at strategic places in a refrigeration system to permit the isolation of single components or selected sections of the system for monitoring, service, or repair.

Information Sheet

c. Shut-off valves help eliminate the need for accessing a system at a point that might permit refrigerant to be expelled into the atmosphere or where air might enter into a system.

Note: The following Henry Valve Company graphic demonstrates the many places a shut-off valve would benefit component and system service in a typical system.


Filter-drier
Evaporator
Suction line filter
Condenser
Accumulator
Oil separator
Receiver
● Shut-off valves

Courtesy Henry Valve Company

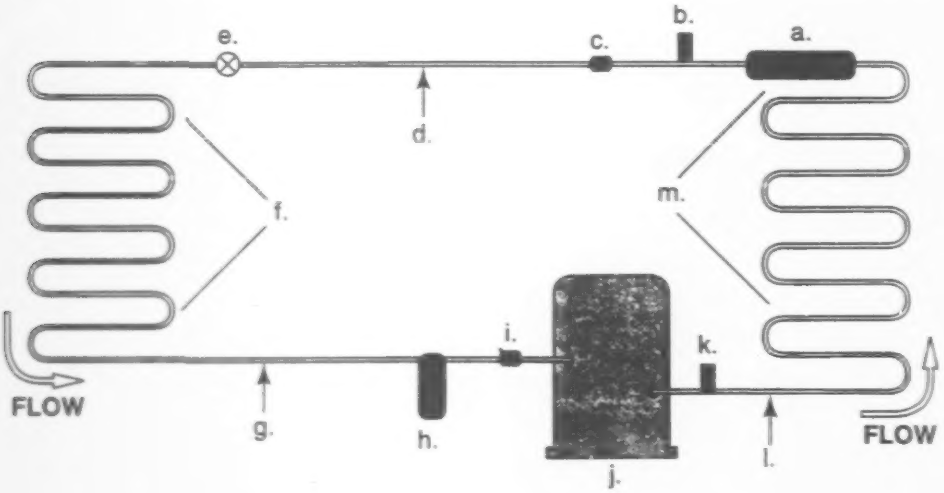
Refrigeration System Accessories
Unit 12

Assignment Sheet 1—Identify Components of a Mechanical Refrigeration System With Accessories

Name ______________________________ Overall Rating ______________

Evaluation criteria	Rating
Number of identifications attempted	_____
Number of identifications correct	_____

Directions: Examine the following graphic and insert the proper component name in the blank beside the letter that indicates its position in the system.



a. ______________ b. ______________ c. ______________

d. ______________ e. ______________ f. ______________

g. ______________ h. ______________ i. ______________

j. ______________ k. ______________ l. ______________

m. ______________

Refrigeration System Accessories
Unit 12

Assignment Sheet 2—Select Functions for Refrigeration System Accessories

Name ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of functions selected	_____
Number of correct functions corrected	_____
Percentage of correct answers	_____

Directions: The following situations reflect functions for refrigeration system accessories. Select the answer that defines the best assessment of the component function.

a. In an ideal refrigeration system, only vapor comes out of the evaporator so the compressor will not be damaged by liquid refrigerant. In actual operation, liquid is ejected from the evaporator along with oil. To avoid problems, systems may use an accumulator installed where to accomplish what?

   (1) Just before the compressor so that it collects liquid that would otherwise go into the compressor.

   (2) Just after the evaporator so that it can pick up any liquid in the suction line and vaporize it before it reaches the compressor, and also pick up oil in the refrigerant and meter it back to the compressor.

   (3) Just after the evaporator where it acts as a storage facility for excess liquid refrigerant so that oil can settle to the bottom and later be removed for replacement in the compressor as needs require.

b. An oil separator is used on many low temperature refrigeration units and some larger air conditioning systems because it can accomplish the following:

   (1) The separator separates oil from the refrigerant and returns it to the compressor crankcase before it can reach other system components.

   (2) The separator stores oil until it builds up excess pressure, then releases oil in very small quantities to avoid any system damage that large quantities of oil might cause.

   (3) The separator stores oil trapped in the refrigerant so that the oil can be cycled back into the compressor anytime the system cycles off.

Assignment Sheet 2

c. When a large refrigeration system generates high levels of noise and vibration, both situations can be controlled with a certain process.

    (1) Install a vibration eliminator anywhere in the system because nine times out of ten vibration causes noise and both problems can be solved at once.

    (2) Install a muffler just after the compressor and arrange an exterior line to exhaust noise to a deadening baffle enclosure.

    (3) Install a muffler right after the compressor in the discharge line so that it changes discharge pressures directionally, and install a muffler in the discharge line parallel to the crankshaft of the compressor.

d. A filter-drier is so named because it performs dual functions in a refrigeration system. What are the dual functions and how does a filter-drier perform them?

    (1) The filter-drier takes moisture and acid out of a system by using sophisticated acid-removing material and a quick-drying substance to remove moisture.

    (2) The filter-drier uses a desiccant to remove moisture and a material that acts as a magnet to pick up particulate matter.

    (3) The filter-drier uses a desiccant that is strong enough to remove moisture and pick up all contaminants in the system.

Refrigeration System Accessories
Unit 12

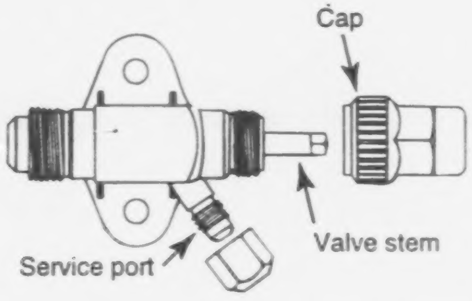
Assignment Sheet 3—Select Operating Positions for Service Valves

Name ______________________________ Overall Rating ____________

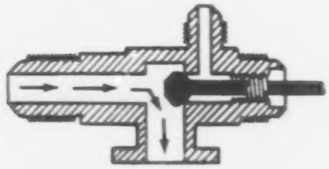
Evaluation criteria	Rating
Number of positions selected	_____
Number of correct positions selected	_____
Percentage of correct answers	_____

Directions: The following situations reflect the need for a service valve to be in a certain position. Read the service condition indicated and select the best answer about valve position.

a. Assume the valve in the following illustration is in a normally operating system so that the nut on the service valve can be safely removed so a manifold gauge set can be connected. The service valve is:

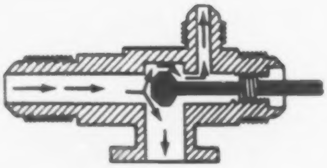


(1) Backseated

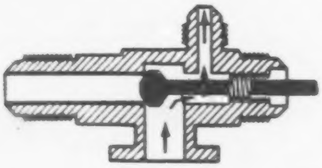


Assignment Sheet 3

(2) Cracked



(3) Frontseated



b. You want the service valve shown in problem a to permit vapor or liquid refrigerant to continue to pass into the component and also into the service port where it can be monitored. The service valve needs to be:

Note: Refer to illustrations (1) (2) and (3) in question a to assist you with your answer.

(1) Backseated

(2) Cracked

(3) Frontseated

c. You want the service valve shown in problem a to allow vapor into a service port where it can be monitored, but you want the valve to shut off vapor supply to the compressor. The service valve needs to be:

Note: Refer to illustrations (1) (2) and (3) in question a to assist you with your answer.

(1) Backseated

(2) Cracked

(3) Frontseated

Refrigeration System Accessories
Unit 12

Job Sheet 1—Find and Identify Refrigeration System Accessories

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Accumulator identified	______
Oil separator identified	______
Muffler/vibration eliminator identified	______
Filter-drier identified	______
Sight glass identified	______
Service valve identified	______
Shut-off valve identified	______

Directions: Your instructor has arranged for you to access a variety of refrigeration systems. Remove protective covers or panels as needed to find the refrigeration system components on each of the systems. When you are ready to identify the accessories on a given system, ask your instructor to evaluate your accessory identifications and check off those you complete properly. In cases where a system may not have all accessories listed, write NA in the blank.

Commercial Refrigeration Unit

1. Accumulator ______
2. Oil separator ______
3. Muffler/vibration eliminator ______
4. Filter-drier ______
5. Sight glass ______
6. Service valve ______
7. Shut-off valve ______

Domestic Refrigerator or Freezer

1. Accumulator ______
2. Oil separator ______
3. Muffler/vibration eliminator ______
4. Filter-drier ______
5. Sight glass ______
6. Service valve ______
7. Shut-off valve ______

Job Sheet 1

Residential Air Conditioning System		Window Air Conditioner	
1. Accumulator	______	1. Accumulator	______
2. Oil separator	______	2. Oil separator	______
3. Muffler/vibration eliminator	______	3. Muffler/vibration eliminator	______
4. Filter-drier	______	4. Filter-drier	______
5. Sight glass	______	5. Sight glass	______
6. Service valve	______	6. Service valve	______
7. Shut-off valve	______	7. Shut-off valve	______

Evaluator's comments: ____

____

____

EPA Regulations for Refrigerant Management and Technician Certification
Unit 13

Objective Sheet

Unit Objective

After completing this unit, the student should be able to solve problems about "no venting" regulations and complete a group of typical questions from a technician certification test. The student should demonstrate this competency by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to EPA regulations for refrigerant management and technician certification with their correct definitions.
2. Complete statements about important historical information about ozone.
3. Solve problems about the ozone-depletion cycle and its causes.
4. Complete statements about types of global warming and how it is measured.
5. Solve problems about ozone depletion and what it means.
6. Complete statements about human environmental concerns about ozone depletion.
7. Complete statements about regulated refrigerants.
8. Solve problems about the prohibition on venting.
9. Solve problems about permitted releases under the "no venting" regulation.
10. Solve problems about service practice requirements.
11. Complete statements about refrigerant leaks and repair requirements.
12. Complete statements about certification procedures.

Objective Sheet

13. Solve problems about contents and conduct of certification tests.
14. Complete statements about training for EPA certification.
15. Answer sample certification test questions. (Assignment Sheet 1)

EPA Regulations for
Refrigerant Management and Technician Certification
Unit 13

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add visual enhancement by making transparencies from materials that apply to the subject areas; make sure materials are copyright approved or your own products.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss and demonstrate the procedures in the assignment sheet, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Impress students with the importance of the EPA regulations that demand different work habits and new attitudes for ACR technicians. This unit addresses the two elements of the EPA regulations that most affect the technicians who work daily in ACR service. If you have back copies of *The Air Conditioning, Heating, and Refrigeration News*, sort out copies that have stories about the EPA regulations and discussions about their impact on the ACR industry. Assign students in groups to read specific articles and report to the class how the articles affect entry-level ACR technicians. Skill areas: **Group effectiveness skills, teamwork.**

2. If you have purchased EPA certification training materials from one of the training agencies designated by the EPA, have students examine some sample test questions so they'll have an idea of how the tests are structured. Assignment Sheet 1 attempts to duplicate a typical test style, but it will service students well to see how subjects are handled by another training agency. Skill areas: **Foundation skills, reading.**

3. Invite a local contractor to talk about EPA certification as it has affected technicians who work in your locale. Ask one or two of the technicians to talk about the test and what students can study to make sure they qualify for certification. Skill areas: **Foundation skills, listening.**

4. This unit and the remaining units of this text are specifically designed to help students pass the tests for Type I and Type II certification. The units following this one cover the important elements of recovery, recycling, and reclaiming, handling cylinders safely and legally, and pressurizing and leak testing. All activities pay strict attention to "de minimus" venting regulations with constant reminders in the hands-on job sheets. If you have need for materials dedicated to Type III or Universal Certification, some of those are listed in the supplemental resources that conclude suggested activities.

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

Suggested Activities

2. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994, 1995.

3. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

Stratospheric Ozone Protection Final Rule Summary from the EPA itself is a brief, but well prepared overview of the refrigerant recycling rules in Section 608 of the Clean Air Act of 1990. This 12-page document covers more than 20 important areas and is complete with an important list of definitions. The "overview" is available from the Environmental Protection Agency. Call the Stratospheric Ozone Information Hotline at 1-800-296-1996. The hotline service is open from 10 a.m. to 4 p.m. Eastern Time.

Note: The hotline is also the source for other vital materials about Section 608 and other information related to the new EPA regulations.

Among the many training manuals available for studying for the new EPA certification tests is a product of ACCA, Air Conditioning Contractors of America, in cooperation with a technical staff from Ferris State University in Big Rapids, Michigan. *Refrigerant Transition and Recovery Certification Program for HVACR Technicians* covers the materials in Section 608 almost item by item. The text treats all important subject fully and is well illustrated for information, write:

Air Conditioning Contractors of America
1712 New Hampshire Avenue, NW
Washington, DC 20009

Or call ACCA at (202) 234-4721.

Refrigerant Containment Applicant Study Guide from Video General, Inc. is another manual dedicated to help students prepare for the EPA certification tests. The text is complete with good examples of refrigeration processes, and the service demands reflected in the test banks used for certification testing. this is another well-illustrated text that includes good samples of test questions. For information write:

VGI Training Division
Video General, Inc.
1156 107th Street
Arlington, TX 76011

Or call VGI Training Division at (817) 640-8333

EPA Regulations for
Refrigerant Management and Technician Certification
Unit 13

Answers to Assignment Sheet 1

Assignment Sheet 1

A. 2
B. 4
C. 1
D. 3
E. 1
F. 3
G. 5
H. 5

EPA Regulations for Refrigerant Management and Technician Certification
Unit 13

Answers to Written Test

1. a. 7
   b. 3
   c. 6
   d. 1
   e. 5
   f. 2
   g. 4

2. a. 1840, 1881
   b. ozone-monitoring
   c. "miracle chemicals"
   d. CFCs
   e. "ozone hole"
   f. McMurdo Station, Antarctica
   g. South Pole
   h. London Amendments
   i. 1996
   j. Copenhagen

3. a. (1)
   b. (2)

4. a, b, c, d

5. a. cumulative
   b. ionizing
   c. ultraviolet
   d. occlude
   e. fight off
   f. accelerates
   g. flooding

6. a, b

7. a. I
   b. II
   c. 1995
   d. global warming

8. a. knowingly
   b. $25,000 (twenty-five thousand dollars)
   c. self-effectuating
   d. violating

Answers to Written Test

9. a, c

10. a. (2)
    b. (2)

11. b, c, d, e

12. a, d, f, g, h, i

13. a. 25, 25
    b. 100, 25, 75
    c. pressure/temperature chart

14. a, b, c, d

EPA Regulations for Refrigerant Management and Technician Certification
Unit 13

Written Test

Name ________________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions. Definitions continue on next page.

______a. The layer of air surrounding the earth, estimated to range as high as 600 to 700 miles

______b. An increase in the average temperature of the earth's surface brought on by retention of infrared radiation in the troposphere and by ozone depletion in the stratosphere

______c. An increase in earth's temperature brought on by tropospheric pollution that causes infrared radiation to be reflected back to the earth rather than away from it

______d. An increase in the earth's temperature brought on by chemical destruction of the protective stratospheric layer of ozone that cuts off ultraviolet rays from the sun

______e. Someone appointed to monitor students taking a test

______f. An atmospheric region surrounding the earth at an altitude ranging from about 30 miles at the equator to approximately 7 miles at the poles

______g. An atmospheric region immediately surrounding the earth and extending upward to the lower boundary of the stratosphere

1. Ozone depletion
2. Stratosphere
3. Global warming
4. Troposphere
5. Proctor
6. Greenhouse effect
7. Atmosphere

Written Test

2. Complete statements about important historical information about ozone. Circle the material that best completes each of the following statements.

   a. In (**140**) (**1920**), ozone was first discovered by C. F. Shoenbin, and from 1879 until (**1881**) (**1921**), W. N. Hartley and A. Cornu discovered the ozone layer in the stratosphere and established its relation to the cutoff of ultraviolet rays from the sun.

   b. As early as the 1920s, G. M. B. Dobson discovered that ozone production was maximum during spring at high altitudes, and that stratospheric winds transport ozone around the globe, and modern (**ozone-monitoring**) (**stratospheric-weather**) stations around the world are named in honor of Mr. Dobson.

   c. CFCs were invented in 1928 by T. Midgley, were first used as refrigerants in the mid-30s, and by the 1950s, had become known as the (**"miracle chemicals"**) (**"modern chemicals"**) and were used in everything from refrigerators and freezers to spray cans and solvents.

   d. In the 1970s, scientific efforts in response to SST exhausts in the atmosphere proved how fragile the ozone layer really is, and also in the 70s, Molina and Rowland verified that ground-level (**CFCs**) (**CO_2s**) rise into the stratosphere, break down, and start destroying ozone.

   e. In 1979, Canada, Norway, Sweden, and the U.S. all banned aerosol sprays, but with the revival of CFC use in the 1980s, ozone studies were intensified, and in 1985, scientists monitoring the springtime ozone layer above Halley Bay, Antarctica discovered what has become known as the (**"ozone hole"**) (**"ozone problem"**).

   f. In 1986, a National Ozone Expedition at (**McMurdo Station, Antarctica**) (**the North Pole**), established that chlorine and bromine compounds were the likely culprits causing ozone depletion.

   g. Finally, in response to fear of the "ozone hole" over the (**South Pole**) (**North Pole**), 22 nations met in 1987, and signed the Montreal Protocol designed to freeze production of CFCs and halon products, but further studies in 938 verified that ozone depletion was also happening over the Northern Hemisphere and as far north as the Arctic—in other words, the problem was global.

   h, Because continued scientific evidence indicated a greater global problem than as first suspected, the Montreal Protocol was amended by the (**London Amendments**) (**Second Montreal Protocol**) in 1990 to speed up the phaseout time limit for CFCs.

i. In America, the phaseout was moved up to January, 2000, by the 1990 Clean Air Act, and in 1992, the Copenhagen Amendments to the Montreal Protocol moved the phaseout cutoff to January, (**1996**) (**1997**).

j. The EPA modified its Clean Air Act regulations to agree with the (**Copenhagen**) (**London**) Amendments, and if any other amendments to the Montreal Protocol prove stricter than the CAA regulations, the stricter regulations apply.

3. Solve problems about ozone depletion and its causes. Circle the number in front of the statement that best solves each of the following problems.

a. Another student is trying to explain how ozone destruction occurs in the atmosphere, and wants to know if you can help. To solve the problem, you could:

(1) Start with a simple reference to the fact that ozone is made up of three atoms of oxygen, O_3, chlorine atoms that break away from CFC molecules that reach the stratosphere replace an O atom in the O_3 structure, and start the chain reaction that destroys the ozone layer.

(2) Comment about the renegade chlorine atoms in the CFCs that are released into outer space.

(3) Try to pinpoint the CFC molecule as the culprit and show how it is released into the lower atmosphere and then reaches the stratosphere where it interrupts the ultraviolet activity there.

b. In discussing the ozone-depletion theory, someone says the problem is confined to the South Pole and that all the stir about controlling CFC venting is "for the birds." The attitude is a common argument against the ozone-depletion theory, but to clear up the problem, you could:

(1) Remind the speaker that scientists have studied the ozone for more than a century and have records to prove their theories.

(2) Point out to the speaker that high velocity solar winds blow CL atoms all around the world where they continue to break up the O_3 molecules and destroy the ozone layer; in other words, the problem is global.

(3) Tell the speaker to study the problem more before coming up with opinions that can't be supported with facts.

Written Test

4. Select true statements about ozone depletion potential and what it means. Place an "X" beside each true statement.

   ______a. Ozone in the troposphere is one of the "bad guys" because it combines with pollutants to form smog and contributes to global warming, but in the stratosphere, ozone is definitely a good guy because it provides a vital protective barrier from damaging ultraviolet (UV-B) radiation from the sun.

   ______b. In EPA regulations, substances are assigned ozone depletion potential in reference to a base of 1.00 for CFC-11.

   ______c. CFCs have been singled out as the greatest contributors to ozone depletion, not only because they do contribute significantly to depletion, but because they are single, stable compounds, and may survive more than a hundred years int he stratosphere and continue to contribute to ozone destruction all that time.

   ______d. Although the halons appear to be most destructive to the ozone, their use is minor when compared to CFCs and HCFCs, so it is easy to see why the CFCs are number one on the EPA "hit list" with the HCFCs close behind.

   ______e. The HFCs, such as HFC-134a, have a medium ODP, they are still subject to the "no venting" regulation because they have a potential to contribute to global warming.

5. Complete statements about human and environmental concerns about ozone depletion. Circle the material that best completes each of the following statements.

   a. Certain electromagnetic frequencies serve as vehicles for transporting radio and TV broadcasting, microwaves for ovens, and infrared devices for medicine and industry: these frequencies, measured in HZ, have long wavelengths, are not ionizing, and are not (**cumulative**) (**damaging**) to the human body.

   b. Other electromagnetic frequencies such as X-rays also serve mankind when properly contained and programmed, but ultraviolet rays, especially UV-B, are dangerous to humans because they are (**ionizing**) (**deadly**), meaning they can cause chemical and biological changes in a person, and they are cumulative, meaning that they build up with repeated exposure.

   c. Because a depleted ozone layer permits a greater number of (**ultraviolet**) (**infrared**) rays to reach the surface of the earth, people are in greater danger from skin cancer, particularly malignant melanoma, a type of skin cancer that causes more than 25,000 deaths around the world each year.

   d. Increased ultraviolet exposure will also increase the incidence of cataracts that (**occlude**) (**destroy**) the lenses in the eyes, restrict vision, and cause blindness.

Written Test

e. Increased ultraviolet exposure will also decrease the ability of the body's immune response system to (**fight off**) (**stop**) disease.

f. Excessive ultraviolet exposure (**accelerates**) (**prolongs**) the deterioration of plastics and many kinds of polymers that are used for protective coatings, insulation, and paint, and could contribute to large increases in the cost of industrial maintenance.

g. Too much global ultraviolet exposure could seriously affect agricultural cycles, marine plant life, patterns of winds and rainfall, and generally upset ecosystems around the world leading to natural disasters such as (**flooding**) (**fire**) and famine.

6. Select true statements about types of global warming and how it is measured. Place an "X" beside each true statement.

______a. The direct cause of global warming is partly carbon monoxide and carbon dioxide, but also CFCs, HCFCs, and HFCs, and the standard by which a substances direct global warming potential is measured is related to CFC-11 which has a base of 1.00.

______b. The indirect cause of global warming is the emission of CO_2 created by the combustion of fossil fuels, and the standard by which a substances indirect global warming potential is measured is related to CO_2 which has a base of 1.00.

______c. The total effect of all contributors to global warming is known at TGWP, Total Global Warming Potential, and is the sum of the indirect potential and direct potential of substance added together.

7. Complete statements about regulated refrigerants. Write in the word(s) or information needed to complete each of the following statements.

a. In the Clean Air Amendments, the EPA identifies CFCs as Class ____________ substances.

b. In the Clean Air Amendments, the EPA identifies HCFCs as Class ____________ substances.

c. Production of CFCs should have stopped in ____________.

d. HFCs are not classified by the EPA because they contain no hydroflurocarbons, but they are subject to "no venting" regulations because they contribute to ____________ ____________.

Written Test

8. Complete statements about the prohibition on venting. Write in the information required to complete each of the following statements.

   a. The "no venting" regulation prohibits individuals from ____________ venting ozone-depleting compounds into the atmosphere while servicing ACR equipment.

   b. Persons and companies who violate the "no venting" regulation are subject to fines of up to ____________ per day.

   c. The "no venting" regulation is "____________-____________" meaning that individuals are personally responsible for compliance.

   d. If a technician tops off a system that is known to be leaking, the technician may be ____________ the "no venting" regulation.

9. Select true statements about permitted releases under the "no venting" regulation. Place an "X" beside each true statement.

   ______a. A technician making a "good faith" attempt to safely recycle or dispose of refrigerant may, of necessity, have to release a very small amount of refrigerant in purging, hooking up hoses, or some other procedures; these "de minimus" releases are permitted.

   ______b. Refrigerants emitted from mechanical purging or leaks during the normal operation of ACR equipment are permitted, and this also includes emissions during maintenance, service, repair, or disposal.

   ______c. Mixtures of nitrogen and R-22 used as holding charges or as leak test gases may be vented because the ozone-depleting compound is not being used as a refrigerant, but, a technician cannot add nitrogen to a charged system to avoid recovering refrigerant; the system must be evacuated to an appropriate level before nitrogen is added.

   ______d. The small "de minimus" releases of refrigerant resulting from purging hoses or from connecting or disconnecting hoses to charge or service appliances are considered a violation, and recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

Written Test

10. Solve problems about refrigerant leaks and repair requirements. Circle the number beside the statement that best solves each of the following problems.

    a. A store owner knows that AC equipment on the property has a minor refrigerant leak, but wants to wait until after summer weather to have the system cared for. The owner's problem is that she wants to be sure he is not violating the law, so to solve the problem you should:

        (1) Inform the owner that unless it is really a major leak there will be no violation, and waiting until after summer cooling demands is a wise thing to do.

        (2) Check the system to see if it has more than a 50-pound refrigerant charge, and if it does, and if the leak is substantial it should be repaired as soon as the work can be scheduled.

    b. A manufacturing concern has a large system that is suspected of leaking, but monitoring such a system is almost impossible. How can you find out if the system is leaking and how much it is leaking?

        (1) Set up leak-monitoring stations at four different points in the system, monitor for at least a week, and then average the results to determine how much of a leak there is.

        (2) Records the company should maintain show how much refrigerant was placed in the system and when; this information will help determine whether or not the system is leaking.

11. Select true statements about service requirements. Place an "X" beside each true statement.

    Note: For a statement to be true, all parts of the statement must be true.

    ______a. Technicians are required to evacuate ACR equipment to reasonable vacuum levels related to the date of manufacture of the equipment being used, and the recovery equipment must be registered exclusively with the EPA.

    ______b. Recovery or recycling equipment manufactured before November 15, 1993, must be able to evacuate a system to EPA-approved levels, but for equipment manufactured on or after that date, the EPA generally does not require as deep an evacuation capacity, and those evacuation levels are published by the EPA as Table 1 of the CAA.

    ______c. Exceptions to the evacuation requirements include repairs to leaky equipment, and repairs that are not major and that are not followed by an evacuation of the equipment to the environment.

______d. If the presence of leaks does not permit evacuation to EPA-required levels, or if the refrigerant being recovered would be contaminated, the technician opening the appliance must:

(1) isolate leaking from non-leaking components, if possible.

(2) evacuate non-leaking components to EPA-required levels.

(3) evacuate leaking components to the lowest level that can be obtained, not to exceed 0 psig, without contaminating the refrigerant.

______e. If evacuation of the equipment to the environment is not to be performed when repairs are made, and if the repair is not major, the appliance must:

(1) be evacuated to at least 0 psig before it is opened if it is a high- or very high-pressure appliance.

(2) be pressurized to at least 0 (zero) psig before it is opened if it is a low-pressure appliance.

12. Select true statements about certification procedures. Place an "X" beside each true statement.

______a. Type II, Type III, and Universal technicians must pass a test provided by an EPA-approved certifying program.

______b. All the certification tests are strictly closed-book tests administered at designated test sites and conducted in the presence of a proctor.

______c. Both Type II and Type III tests require 90% as a passing grade.

______d. The Type I test may be taken at a test site as a closed-book exam, or it may be taken by mail as an open-book exam.

______e. The on-site test for Type I certification requires 85% as a passing mark, and the mail-in test for Type I certification requires a 90% passing mark.

______f. A technician who passes all three tests is entitled to be issued a Universal Technician certification card.

Written Test

______g. In all cases, the test-administering agency must mail certification cards to qualified technicians within 30 days after the test is administered.

______h. The wallet-sized technician identification card may contain the name of the administering EPA-approved testing agency, but must contain a statement showing the technician's name and listing the type(s) of certification successfully completed.

______i. Once certified, a technician is permanently certified and will not have to retest or recertify in the future.

13. Complete statements about contents and conduct of certification tests. Write in the information that best completes each of the following statements.

    a. The Type I, Type II, and Type III certification tests all have ____________ questions about the "core" of the EPA regulations, plus ____________ questions about the specific area for which the technician is being tested.

    b. The Universal Technician Test has ____________ questions, ____________ questions about the EPA regulations, and ____________ questions about certain areas of ACR service.

    c. The only items an applicant for certification may use during the test are limited to a calculator and a ____________/____________ ____________.

14. Select true statements about training for EPA certification. Place an "X" beside each true statement.

______a. EPA does not review or approve any training materials or courses designed to help applicants prepare for a certification test, but training materials are provided by many of the agencies that EPA has approved to administer the test.

______b. Applicants may voluntarily participate in review or training programs as they feel the need, and many organizations have training programs that vary in scope and content.

______c. Many applicants will find test-specific training materials available through companies they work for, trade or vocational schools they attend, or professional organizations to which they belong.

Written Test

______d. Many of the agencies who administer the EPA certification test have training materials available for an additional fee, and many of these programs contain not only written materials, but videos that enhance those written materials.

______e. Many of the agencies who administer the test and have training materials, suggest time lines for review and test taking; success rates seem to be generally better when applicants have reviewed materials many weeks, or sometimes even a few months, before taking a test.

*Permission to duplicate this test is granted.

EPA Regulations for
Refrigerant Management and Technician Certification
Unit 13

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Answer Sample Certification Test Questions Rating _____

Comments: ____

____

Other ____

____

Written Tests: Pretest _____ Posttest _____

Total _____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

EPA Regulations for Refrigerant Management and Technician Certification
Unit 13

Information Sheet

1. **Terms and definitions**

   a. **Atmosphere** — The layer of air surrounding the earth, estimated to range as high as 600 to 700 miles

   b. **Global warming** — An increase in the average temperature of the earth's surface brought on by retention of infrared radiation in the troposphere and by ozone depletion in the stratosphere

   c. **Greenhouse effect** — An increase in earth's temperature brought on by tropospheric pollution that causes infrared radiation to be reflected back to the earth rather than away from it

   d. **Ozone depletion** — An increase in the earth's temperature brought on by chemical destruction of the protective stratospheric layer of ozone that cuts off ultraviolet rays from the sun

   e. **Proctor** — Someone appointed to monitor students taking a test

   f. **Stratosphere** — An atmospheric region surrounding the earth at an altitude ranging from about 30 miles at the equator to approximately 7 miles at the poles

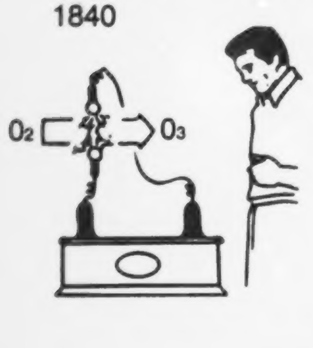
   g. **Troposphere**— An atmospheric region immediately surrounding the earth and extending upward to the lower boundary of the stratosphere

2. **Important historical information about ozone**

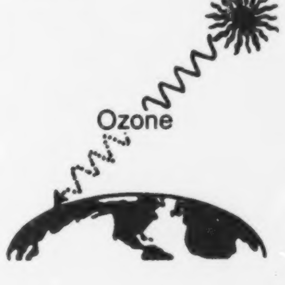
   Note: Adapted from *EarthQuest*, a publication of the Office of Interdisciplinary Earth Studies.

   a. In 1840, ozone was first discovered by C. F. Shoenbin, and from 1879 until 1881, W. N. Hartley and A. Cornu discovered the ozone layer in the stratosphere and established its relation to the cutoff of ultraviolet rays from the sun.

1840



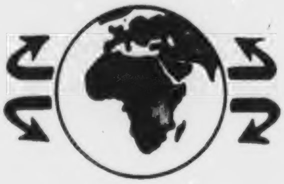
1880



Information Sheet

b. As early as the 1920s, G. M. B. Dobson discovered that ozone production was maximum during spring at high altitudes, and that stratospheric winds transport ozone around the globe, and modern ozone-monitoring stations around the world are named in honor of Mr. Dobson.

Late 1920's

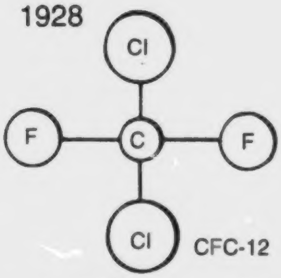


1957

Dobson Stations

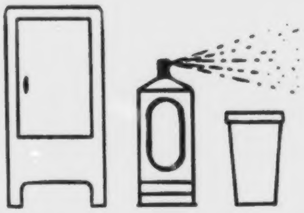
c. CFCs were invented in 1928 by T. Midgley, were first used as refrigerants in the mid-30s, and by the 1950s, had become known as the "miracle chemicals" and were used in everything from refrigerators and freezers to spray cans and solvents.

1928



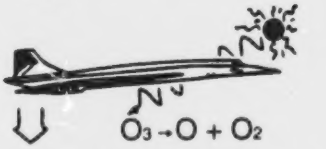
CFC-12

1950s



d. In the 1970s, scientific efforts in response to SST exhausts in the atmosphere proved how fragile the ozone layer really is, and also in the 70s, Molina and Rowland verified that ground-level CFCs rise into the stratosphere, break down, and start destroying ozone.

1970



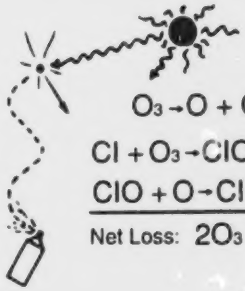
$O_3 \rightarrow O + O_2$

$NO + O_3 \rightarrow NO_2 + O_2$

$NO + O \rightarrow NO + O_2$

Net Loss: $2O_3 \rightarrow 3O_2$

1974



$O_3 \rightarrow O + O_2$

$Cl + O_3 \rightarrow ClO + O_2$

$ClO + O \rightarrow Cl + O_2$

Net Loss: $2O_3 \rightarrow 3O_2$

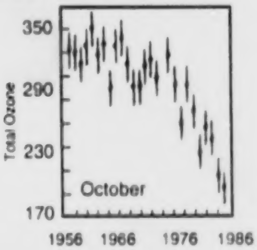
Information Sheet

e. In 1979, Canada, Norway, Sweden, and the U.S. all banned aerosol sprays, but with the revival of CFC use in the 1980s, ozone studies were intensified, and in 1985, scientists monitoring the springtime ozone layer above Halley Bay, Antarctica discovered what has become known as the "ozone hole".

1979

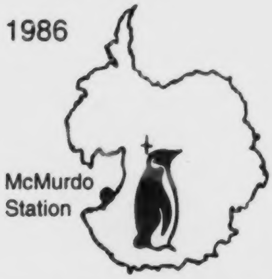
United States
Canada
Norway
Sweden

1985 Halley Bay Station



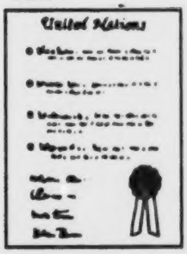
f. In 1986, a National Ozone Expedition at McMurdo Station, Antarctica, established that chlorine and bromine compounds were the likely culprits causing ozone depletion.

1986

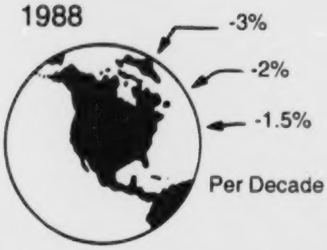


g. Finally, in response to fear of the "ozone hole" over the South Pole, 22 nations met in 1987, and signed the Montreal Protocol designed to freeze production of CFCs and halon products, but further studies in 988 verified that ozone depletion was also happening over the Northern Hemisphere and as far north as the Arctic—in other words, the problem was global.

1987



1988



h. Because continued scientific evidence indicated a greater global problem than as first suspected, the Montreal Protocol was amended by the London Amendments in 1990 to speed up the phaseout time limit for CFCs.

Information Sheet

i. In America, the phaseout was moved up to January, 2000, by the 1990 Clean Air Act, and in 1992, the Copenhagen Amendments to the Montreal Protocol moved the phaseout cutoff to January, 1996.

j. The EPA modified its Clean Air Act regulations to agree with the Copenhagen Amendments, and if any other amendments to the Montreal Protocol prove stricter than the CAA regulations, the stricter regulations apply.

YEAR	MONTREAL PROTOCOL	COPENHAGEN AMENDMENTS	1990 CLEAN AIR ACT
1991	100%	100%	85%
1992	100%	75%	80%
1993	80%	50%	75%
1994	80%	25%	65%
1995	50%	25%	50%
1996	50%	0%	40%
1997	15%	0%	15%
1998	15%	0%	15%
1999	15%	0%	15%
2000	0%	0%	0%

Chart is from the Forane© Retrofit Training Guide. Reprinted with permission.

3. Ozone depletion and its causes

a. Ozone is formed when single oxygen molecules, O_2, in the stratosphere absorb ultraviolet rays from the upper atmosphere and break up into single atoms, O (for now, think of it as O_1); the single oxygen atoms, O_1, then combine with oxygen molecules, O_2, to form ozone, O_3, because $O_1 + O_2 = O_3$.

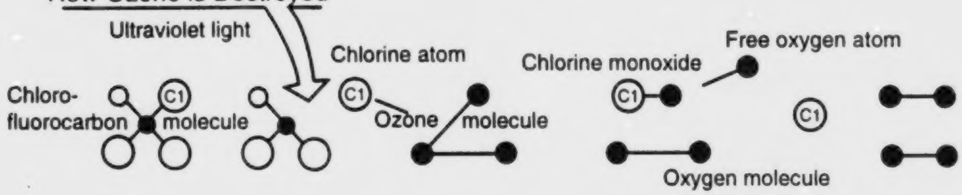
b. The ongoing action of the O atoms combining with O_2 molecules keeps forming ozone, and maintains the protective ozone layer that protects the earth from damaging ultraviolet radiation.

c. In the presence of ultraviolet light, and through a process called "photolysis", a chlorine atom breaks away form a CFC molecule, and the chlorine atom attacks and destroys the O_3 molecule by displacing one of the oxygen atoms with a chlorine atom to form CLO, chlorine monoxide instead of ozone.

Information Sheet

d. In turn, the O atom freed from the O_3 molecule displaces the CL atom in the CLO, to form O_2, and this frees the chlorine atom which acts like an atmospheric renegade to continue the cycle of destroying ozone molecules.

How Ozone is Destroyed



e. Because of extremely high velocity solar winds in the stratosphere, the renegade CL atoms can literally be blown around the world, and so the problem of ozone depletion is a global one.

Note: The "hole" in the atmosphere over Antarctica is not a hole, but actually a sparse layer of ozone through which UV-B rays can more easily pass.

f. Critics of the ozone-depletion theory have various arguments against it, but proof does exist for the theory, proof verified by scientific observations that began more than a century ago.

4. Ozone depletion potential and what it means

a. Ozone in the troposphere is one of the "bad guys" because it combines with pollutants to form smog and contributes to global warming, but in the stratosphere, ozone is definitely a good guy because it provides a vital protective barrier from damaging ultraviolet (UV-B) radiation from the sun.

b. In EPA regulations, substances are assigned ozone depletion potential in reference to a base of 1.00 for CFC-11.

Substance	ODP (Ozone Depletion Potential)*
CFC-11	1.00 (Base)
CFC-12	0.93
Halon-1301	10.0
HCFC-22	0.05
HFC-143a	0.0

*List is partial and used for example only

Information Sheet

c. CFCs have been singled out as the greatest contributors to ozone depletion, not only because they do contribute significantly to depletion, but because they are single, stable compounds, and may survive more than a hundred years in the stratosphere and continue to contribute to ozone destruction all that time.

d. Although the halons appear to be most destructive to the ozone, their use is minor when compared to CFCs and HCFCs, so it is easy to see why the CFCs are number one on the EPA "hit list" with the HCFCs close behind.

e. The HFCs, such as HFC-134a, have a zero ODP, they are still subject to the "no venting" regulation because they have a potential to contribute to global warming.

5. Human and environmental concerns about ozone depletion

a. Certain electromagnetic frequencies serve as vehicles for transporting radio and TV broadcasting, microwaves for ovens, and infrared devices for medicine and industry: these frequencies, measured in HZ, have long wavelengths, are not ionizing, and are not cumulative to the human body.

b. Other electromagnetic frequencies such as X-rays also serve mankind when properly contained and programmed, but ultraviolet rays, especially UV-B, are dangerous to humans because they are ionizing, meaning they can cause chemical and biological changes in a person, and they are cumulative, meaning that they build up with repeated exposure.

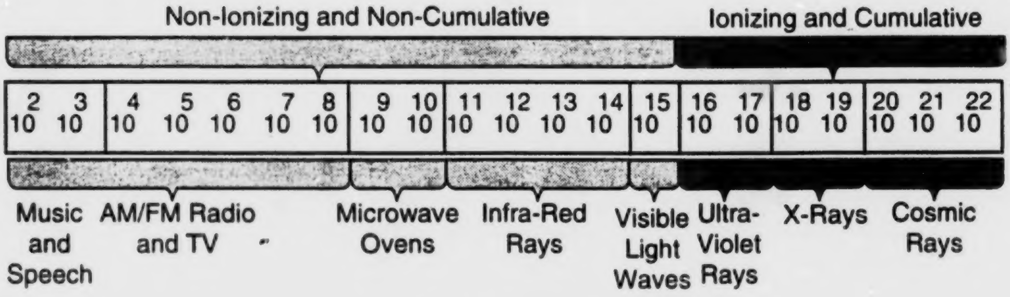
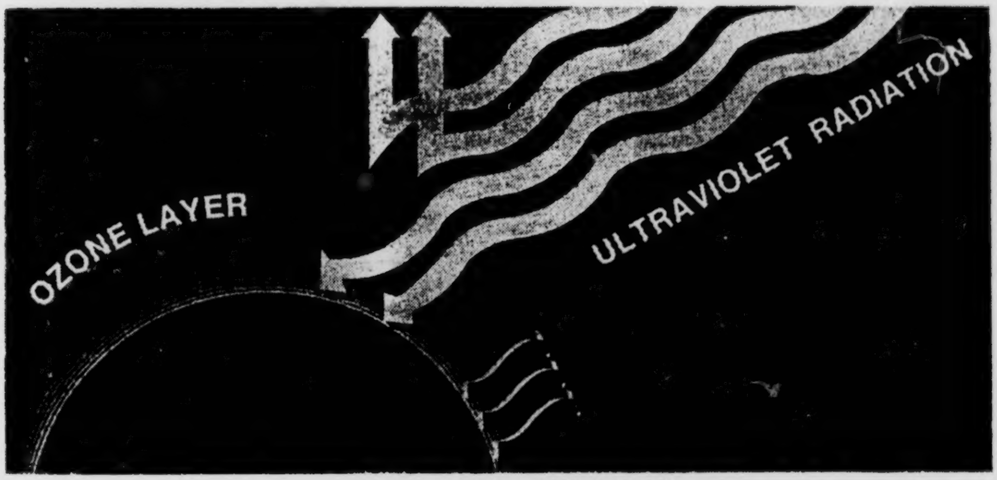

Non-Ionizing and Non-Cumulative
Ionizing and Cumulative
10^{2} 10^{3}
10^{4} 10^{5} 10^{6} 10^{7} 10^{8}
10^{9} 10^{10}
10^{11} 10^{12} 10^{13} 10^{14}
10^{15}
10^{16} 10^{17}
10^{18} 10^{19}
10^{20} 10^{21} 10^{22}
Music and Speech
AM/FM Radio and TV
Microwave Ovens
Infra-Red Rays
Visible Light Waves
Ultra-Violet Rays
X-Rays
Cosmic Rays

Chart shows wavelengths in Hertz

Information Sheet

c. Because a depleted ozone layer permits a greater number of ultraviolet rays to reach the surface of the earth, people are in greater danger from skin cancer, particularly malignant melanoma, a type of skin cancer that causes more than 25,000 deaths around the world each year.



Courtesy Environmental Protection Agency

d. Increased ultraviolet exposure will also increase the incidence of cataracts that occlude the lenses in the eyes, restrict vision, and cause blindness.

e. Increased ultraviolet exposure will also decrease the ability of the body's immune response system to fight off disease.

Note: Tropical countries where ultraviolet exposure is high have a greater incidence of certain varieties of herpes, and leishmaniasis, a parasitic disease of the blood system.

f. Excessive ultraviolet exposure accelerates the deterioration of plastics and many kinds of polymers that are used for protective coatings, insulation, and paint, and could contribute to large increases in the cost of industrial maintenance.

g. Too much global ultraviolet exposure could seriously affect agricultural cycles, marine plant life, patterns of winds and rainfall, and generally upset ecosystems around the world leading to natural disasters such as flooding and famine.

Note: People of Australia are well aware of the problem of ozone depletion, and "ozone alerts" are sometimes issued as part of Australian weather reports. An "ozone alert" encourages people to stay inside as much as possible and to wear polarized sun glasses and sun screen when they have to go outdoors. In other words, ozone depletion problems are not just down the road—they are here!

Information Sheet

6. Types of global warming and how it is measured

a. Global warming is caused by atmospheric pollutants that absorb and reflect infrared radiation back to the earth's surface and contribute to an increase in the earth's average temperature.

a. The "direct" cause of global warming is partly carbon monoxide and carbon dioxide, but also CFCs, HCFCs, and HFCs, and the global warming potential for a substance is measured with respect to CFC-11 which has been established with a base of 1.00 so other substances contributing "directly" to global warming can be compared with it.

c. Substances that contribute to global warming directly are given a GWP, Global Warming Potential rating.

Refrigerant	GWP Rating (Direct Effect)*
CFC-11	1.00 (Base)
CFC-12	3.10
R-502	4.10
HCFC	0.35
HFC-134a	0.27

*List is partial and used for example only

d. The "indirect" cause of global warming is the emission of carbon dioxide, CO_2, created by the combustion of fossil fuels used to generate electricity to run ACR equipment, and since CO_2 is the major contributor to "indirect" global warming, it has been given a base of 1.00 so that other substances contributing to "indirect" global warming can be compared with it.

Refrigerant	GWP Rating (Indirect Effect)*
CO_2	1.00 (Base)
CFC-11	1,300
CFC-12	3,700
CFC-115	13,800
HFC-134a	400

*List is partial and used for example only

Information Sheet

e. The indirect GWP is measured with CO_2 at a base of 1.00, and CFC-115 at a sky high (pardon the pun) potential of 13,800, but the more important measurement is the combination of direct and indirect GWP which is called the TEWI (Total Equivalent Warming Impact), and this rating also shows that CFCs and HCFCs are big contributors to global warming and the major contributors to ozone depletion.

Note: See Student Supplement 1 for insight into the EPA effort not only to curb the use of CFCs and HCFCs, but to encourage the development of highly-efficient ACR equipment.

7. Regulated refrigerants

a. In the Clean Air Amendments, the EPA has specifically targeted two groups of refrigerants, they are the CFCs, termed Class I substances and HCFCs, termed Class II substances.

b. The CFCs, halons, and other Class I substances are divided into groups:

  (1) Class I, Group I substances which include chloroflurocarbons CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115,

  (2) Class I, Group II substances which include halon 1211, halon 1301, and halon 2402,

  (3) Class I, Group III substances which include chloroflurocarbons CFC-13, CFC-111, CFC-112, CFC-211, CFC-212, CFC-213, CFC-214, CFC-215, CFC-216, and CFC-217,

  (4) Class I, Group IV substance, carbon tetrachloride,

  (5) Class I, Group V substance methyl chloroform

c. The HCFCs, or class II substances include 33 hydrochloroflurocarbons ranging from HCFC-21 to HCFC-271.

d. Production of CFCs should have stopped in 1995, and production of HCFCs will be phased out by 2015, but in the meantime, CFCs may be used only as recycled or reclaimed refrigerants, and HCFCs may be used alone or as blends to replace CFCs in new equipment or retrofit.

e. The HFCs, hydroflurocarbons, are not classified by the EPA because they contain no chlorine, but they are subject to "no venting" regulations because of their potential to contribute to global warming.

Information Sheet

8. The prohibition on venting

a. Section 608 of the CAA prohibits individuals from knowingly venting ozone-depleting compounds into the atmosphere while servicing ACR equipment.

Note: The "no venting" regulation went into effect July 1, 1992, with respect to CFCs and HCFCs, and "no venting" of HFCs was added to the regulations as of November 15, 1995.

b. Persons and companies who violate the "no venting" regulation are subject to fines of up to $25,000 per day.

c. EPA terms the "no venting" law as "self-effectuating", meaning that anyone working on ACR equipment is personally responsible for complying with the regulation—a kind of honor system.

d. The EPA cannot police the "no venting" regulation, but they do offer a reward of up to $10,000 to individuals who report proven violations of the law, and persons or companies who buy refrigerant and fail to keep proper paperwork to account for it may be subject to fines.

Note: Fines of $25,000 and more have already been levied against several companies who have ignored the "no venting" law, and individuals have already earned "bounty" money for reporting violators.

e. A technician topping off a system that is known to be leaking refrigerant is inadvertently "venting" refrigerant to the atmosphere and may be in violation of the regulation.

9. Permitted releases under the "no venting" regulation

a. A technician making a "good faith" attempt to safely recycle or dispose of refrigerant may, of necessity, have to release a very small amount of refrigerant in purging, hooking up hoses, or some other procedures; these "de minimus" releases are permitted.

b. Refrigerants emitted from mechanical purging or leaks during the normal operation of ACR equipment are permitted, and this does not mean emissions during maintenance, service, repair, or disposal.

c. Mixtures of nitrogen and R-22 used as holding charges or as leak test gases may be vented because the ozone-depleting compound is not being used as a refrigerant, but, a technician cannot add nitrogen to a charged system to avoid recovering refrigerant; the system must be evacuated to an appropriate level before nitrogen is added.

d. The small "de minimus" releases of refrigerant resulting from purging hoses or from connecting or disconnecting hoses to charge or service appliances are not considered a violation, but recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

Information Sheet

10. Refrigerant leaks and repair requirements

a. Commercial or industrial ACR equipment with charges of more than 50 pounds of refrigerant have to have substantial leaks repaired.

b. The trigger point for establishing the presence of a substantial leak is 35 percent annually for equipment serving industrial processes and commercial refrigeration.

c. The leak rate for other than industrial and commercial equipment is set at 15 percent annually, and this applies to comfort cooling chillers and other equipment with a refrigerant charge of more than 50 pounds.

d. Leak rate may be difficult to establish through monitoring, so the EPA requires owners of ACR equipment with more than a 50 pound refrigerant charge to keep accurate records of refrigerant added to their equipment during servicing and maintenance procedures.

11. Service requirements

a. Technicians are required to evacuate ACR equipment to established vacuum levels related to the date of manufacture of the equipment being used, and the recovery equipment must be registered with the EPA or its appointed authority.

b. Recovery or recycling equipment manufactured before November 15, 1993, must be able to evacuate a system to EPA-approved levels, but for equipment manufactured on or after that date, the EPA generally requires a deeper evacuation capacity, and those evacuation levels are published by the EPA as Table 1 of the CAA.

	Inches of Mercury Vacuum* Using Equipment Manufactured:	
Type of Appliances	Before Nov. 15, 1993	On or after Nov. 15, 1993
HCFC-22 appliance** normally containing less than 200 pounds of refrigerant	0	0
HCFC-22 appliance** normally containing 200 pounds or more of refrigerant	4	10
Other high-pressure appliance** normally containing less than 200 pounds of refrigerant (CFC-12, -500, -502, -114)	4	10
Other high-pressure appliance** normally containing 200 pounds or more of refrigerant (CFC-12, -500, -502, -114)	4	15
Very High Pressure Appliance (CFC-13, -502)	0	0
Low-Pressure Appliance (CFC-11, HCFC-123)	25	25 mm Hg absolute

*Relative to standard atmospheric pressure of 29.9" Hg.

**Or isolated component of such an appliance

Information Sheet

c. Exceptions to the evacuation requirements include repairs to leaky equipment, and repairs that are not major and that are not followed by an evacuation of the equipment to the environment.

d. If the presence of leaks does not permit evacuation to EPA-required levels, or if the refrigerant being recovered would be contaminated, the technician opening the appliance must:

   (1) isolate leaking from non-leaking components, if possible.

   (2) evacuate non-leaking components to EPA-required levels.

   (3) evacuate leaking components to the lowest level that can be obtained, not to exceed 0 psig, without contaminating the refrigerant.

e. If evacuation of the equipment to the environment is not to be performed when repairs are made, and if the repair is not major, the appliance must:

   (1) be evacuated to at least 0 psig before it is opened if it is a high- or very high-pressure appliance.

   (2) be pressurized to at least 0 (zero) psig before it is opened if it is a low-pressure appliance.

   Note: Methods that involve subsequent purging cannot be used after pressurizing a system.

12. Certification procedures

a. Technicians seeking Type II, Type III, and Universal Certification must pass a test provided by an EPA-approved certifying program.

b. Testing for Type II and Type III certification is strictly closed-book, administered at a designated test site, and conducted in the presence of a proctor.

c. Both Type II and Type III tests requires 70% as a passing grade.

d. Testing for Type I certification may be at a test site as a closed-book exam, or it may be taken by mail as an open-book exam.

e. The on-site test for Type I certification requires 70% as a passing mark, and the mail-in test for Type I certification requires an 84% passing mark.

f. A technician who passes all sections is entitled to be issued a Universal Technician certification card.

Information Sheet

g. In all cases, the test-administering agency must mail certification cards to qualified technicians within 30 days after the test is administered.

h. The wallet-sized technician identification card may contain the name of the administering EPA-approved testing agency, but must contain a statement showing the technician's name and listing the type(s) of certification successfully completed.

i. Once certified, a technician is permanently certified and will not have to retest or recertify in the future.

Note: Remember, that regulations regarding Section 608 are subject to change as industry requirements or ecological needs dictate, and the "one-time certification" rule could be modified or changed if such needs arise.

13. Contents and conduct of certification tests

a. Technicians testing for Type I, Type II, and Type III certification receive a total of 50 questions with 25 questions about the "core" of the Clean Air Amendments and especially Section 608, and another 25 questions about the specific area for which the technician is being tested.

Example: A candidate testing for Type II certification would have 25 core questions about the CAA regulations and 25 questions that would be specific to high- and very-high pressure ACR equipment covering areas of maintenance, service, and repair.

b. Certification programs must randomly select questions for each test, so persons who take the test a second time or more will have a totally new test each time it is administered.

c. Applicants may choose to be tested in more than one area, and whether or not more than one section can be taken during a given testing period has to be arranged with the agency administering the test.

d. Persons testing for Universal Technician certification must answer 100 questions which will have 25 questions about the CAA regulations and 75 questions that are specific to certain areas of ACR service.

e. All tests will be conducted at a time and place scheduled by the administering agency, the tests will be closed-book, and a proctor will be present to assure that no cheating takes place.

f. Persons taking a test may use a Pressure/Temperature chart and a calculator during the test, but no other outside material may be used during the test.

Information Sheet

g. Testing agencies are permitted to charge reasonable fees for administering tests, and these fees have to be published in agency literature.

h. Testing requires no hands-on applications and presents no problems about electrical or electronic schematics.

14. Training for EPA certification

a. EPA does not review or approve any training materials or courses designed to help applicants prepare for a certification test, but training materials are provided by many of the agencies that EPA has approved to administer the test.

b. Applicants may voluntarily participate in review or training programs as they feel the need, and many organizations have training programs that vary in scope and content.

c. Many applicants will find test-specific training materials available through companies they work for, trade or vocational schools they attend, or professional organizations to which they belong.

d. Many of the agencies who administer the EPA certification test have training materials available for an additional fee, and many of these programs contain not only written materials, but videos that enhance those written materials.

e. Many of the agencies who administer the test and have training materials, suggest time lines for review and test taking; success rates seem to be generally better when applicants have reviewed materials a few days, or sometimes even a few hours, before taking a test.

EPA Regulations for Refrigerant Management and Technician Certification

Student Supplement 1—Catch 22 vs "Golden Carrots™"

EPA's concern for stopping ozone depletion has a "Catch 22" element that has drawn criticism from a variety of people. Critics insist new ACR equipment and the new refrigerants will not be as efficient as present equipment and refrigerants. The catch 22? The burning of extra fossil fuels required to operate inefficient ACR equipment and refrigerants will produce so much extra CO_2 that the increase in global warming will negate the decrease in ozone depletion.

The criticism has an element of truth, but only so long as the "new" refrigerants, retrofits, and "new" ACR systems fail to perform efficiently. In order to assure that new systems do perform as efficiently or even more efficiently than existing systems, EPA is working with utilities interested in energy conservation and manufacturers of air conditioning and refrigeration equipment to develop and produce super-efficient refrigerators and freezers for the modern home.

The EPA program is called the "Golden Carrot™" Super-Efficient Refrigerator Program (SERP). The program brings utilities and manufacturers together in a quest to develop and market CFC-free refrigerators and freezers that consume 30 percent less energy than efficiency requirements set in 1993 by the National Appliance Energy Conservation Act (NAECA).

The image of the carrot is an appropriate one because the program has incentives worth about $30 million. These funds are from utility companies and will go to the developers of super-efficient refrigerators and freezers.

Frigidaire and Whirlpool are finalists in the development competition. These two firms along with other companies that develop competitive models will share that $30 million carrot. But the good part of the "Golden Carrot™" competition is this: the cost of these new, highly-efficient refrigerators and freezers will be no more than what people pay now for less efficient models.

In a sense, we can have our cake and eat it too, meaning that we can control both global warming and ozone depletion. Furthermore, in the process, we gain high-tech, high-efficiency, environmentally-friendly major appliances—and that should be a golden carrot for everyone.

EPA Regulations for Refrigerant Management and Technician Certification

Student Supplement 2—Equipment Subject to "De Minimus" Venting

Section 608 of the Clean Air Act permits "de minimus" releases of refrigerant in good faith attempts to service ACR equipment. A review of the kinds of ACR equipment affected by the regulation reflects the broad range of areas where ACR technicians work. It is included here for your examination with hopes that it might give you more directions for career planning.

Household refrigeration: Refrigerators and freezers intended primarily for household use although they may be used outside the home.

Other household appliances: Refrigerated appliances such as dehumidifiers, vending machines, ice makers, and water coolers.

Residential Air Conditioning: Includes window units, packaged terminal air conditioners, central air conditioners, light commercial air conditioners, and heat pumps.

Transport refrigeration: Includes refrigerated ship holds, truck trailers, railway freight cars, and other shipping containers.

Retail food: Includes refrigerated equipment found in supermarkets, convenience stores, restaurants, and other food service establishments—small reach-in refrigerators and freezers, refrigerated display cases, walk-in coolers and freezers, and large parallel systems which connect any display cases to a central condensing unit by means of extensive refrigerant piping.

Cold storage warehouses: Used to store meat, produce, dairy products, and other perishable goods.

Commercial comfort air conditioning: Chillers used to regulate the temperature and humidity of offices, hotels, shopping centers, and other large buildings. Chiller types include: centrifugal, reciprocating, and screw-type—each named for the type of compressor used. Centrifugal chillers are the largest, 30,000 to 600,000 sq. ft. with up to 2,000 pounds of refrigerant, and may use CFC-11, CFC-12, CFC-500, or HCFC-22.

Reciprocating chillers, usually the smallest, are typically used to cool up to 30,000 sq. ft. and use CFC-12 or HCFC-22 with charges up to 160 pounds.

Screw-type chillers are typically used to cool areas from 30,000 to 100,000 sq. ft. and are charged with up to 500 pounds of HCFC-22.

Chillers require frequent servicing, are long lasting, and recovery and recycling are already common because of the large amount of refrigerant used.

Student Supplement 2

Industrial process refrigeration: Includes industrial ice machines, ice rinks, and complex customized systems used in manufacturing chemical, petrochemical, and pharmaceutical products. Centrifugal units may be charged with up to 20,000 lbs. of refrigerant.

Motor vehicle air conditioners: Only 40% still contain a charge at time of disposal.

Comfort cooling in vehicles other than trucks and automobiles: Includes trains, airplanes, ships, buses, farm vehicles, and construction equipment.

EPA Regulations for Refrigerant Management and Technician Certification
Unit 13

Assignment Sheet 1—Answer Sample Certification Questions

Name ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
Number of answers attempted	______
Number of answers correct	______

Directions: EPA certification tests are structured with multiple-choice questions that are both easy and difficult—easy because certain answers can be immediately dismissed as inappropriate, but difficult because other answers closely resemble each other, or more difficult because several answers may be correct. Use the process of elimination to get started, then apply critical thinking to the rest of your test-answering. Keep these test-taking tips in mind as you complete this assignment sheet, and later when you take the certification test. Circle only the number of the item that provides the best answer. If you circle more than one answer, you have failed the question.

General Regulations: Clean Air Amendments and Section 608

A. **Services practices** as outlined in Section 608 mean:

(1) A technician must have modern equipment to service modern ACR equipment.

(2) During the servicing and disposal of ACR equipment, the management of ozone-depleting substances must be maximized.

(3) Only high-skilled technicians may work on low-pressure ACR systems.

(4) Refrigerant must be properly inspected before it can be reused.

B. **Certification** outlined in Section 608 means that the EPA or an authorized representative must certify:

(1) All technicians who work on ACR equipment.

(2) Recycling and recovery equipment.

(3) Persons or companies who reclaim refrigerant.

(4) All persons and equipment listed above.

(5) Only persons and equipment listed in items (1) and (2) above.

Assignment Sheet 1

C. **Refrigerant sales** as outlined in Section 608 means:

(1) Certified technicians can purchase refrigerant.

(2) Company owners or appointed representatives can purchase refrigerant.

(3) Persons who have state or local licenses can purchase refrigerant.

(4) None of the above may purchase refrigerant.

D. **Certification** as outlined in the Clean Air Amendments includes:

(1) Everyone involved with handling refrigerant must be certified.

(2) Only technicians who handle refrigerants in any way have to be certified.

(3) Persons involved in service or disposal of ACR equipment have to certify to the EPA that they have required equipment and are complying with EPA regulations.

(4) All of the above statements are true.

E. **Ozone depletion** means:

(1) The protective ozone layer that blocks out damaging ultraviolet rays is being destroyed by certain refrigerant molecules that reach the stratosphere.

(2) That ozone in the total atmosphere is being depleted.

(3) That an ozone hole over the North Pole is permitting uncontrolled amounts of ultraviolet rays to strike the earth and contribute to global warming.

F. The **Montreal Protocol** was signed in 1987, but the London Agreements:

(1) Brought in several other countries into the project.

(2) Set up an international policing bureau to monitor the production of CFCs.

(3) Accelerated the phaseout date for CFCs when ozone depletion was proven to be even a greater problem than suspected at the time of the Montreal Protocol.

Assignment Sheet 1

G. **Excess ultraviolet radiation** causes:

(1) The accelerated weathering of protective coatings such as paints and plastics.

(2) An increase in the incidence of skin cancer in humans.

(3) A probably decrease in the human immune defense capabilities.

(4) Items (1) and (3).

(5) Items (1), (2), and (3).

H. **America's** participation in the Montreal protocol is reflected in:

(1) The Clean Air Act of 1990.

(2) The EPA prohibition on the venting of CFCs into the atmosphere.

(3) Industrial development of replacement refrigerants for CFCs.

(4) None of the above.

(5) All of the above.

Refrigerants, Lubricants and Desiccants Old and New
Unit 14

Objective Sheet

Unit Objective

After completing this unit, the student should be able to compute temperature/pressure relationships and attach a manifold gauge set to service ports. The student should also be able to pressure check a domestic refrigeration system, a residential air conditioning system, a commercial refrigeration system, and determine the type of refrigerant in a refrigeration or air conditioning system. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to refrigerants, lubricants, and desiccants old and new with their correct definitions.
2. Complete statements about problems and challenges for an industry in transition.
3. Complete statements about the EPA SNAP program and its objectives.
4. Match traditional refrigerants with their characteristics.
5. Complete statements about characteristics of blended refrigerants.
6. Solve problems about how to avoid potential problems with new refrigerants.
7. Solve problems about gauges, charts, and pressure/temperature relationships.
8. Complete statements about why pressure/temperature relationships are important.
9. Solve problems about charging a system with a blend.
10. Select true statements about "drop in" and "retrofit" alternative refrigerants.
11. Solve problems about bubble point and dew point and what they mean.

Objective Sheet

12. Complete statements about ACR lubricants and their characteristics.
13. Solve problems about guidelines for adding or changing lubricants.
14. Solve problems about working with synthetic oils.
15. Complete statements about desiccants, their characteristics and uses.
16. Complete statements about refrigerant identification colors and numbers.
17. Compute temperature/pressure relationships. (Assignment Sheet 1)
18. Attach a manifold gauge set to service ports. (Job Sheet 1)
19. Pressure check a domestic refrigeration system. (Job Sheet 2)
20. Pressure check a residential air conditioning system. (Job Sheet 3)
21. Pressure check a commercial refrigeration system. (Job Sheet 4)
22. Determine the type of refrigerant in a refrigeration or air conditioning system. (Job Sheet 5)

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add visual enhancement by making transparencies from materials that apply to the subject areas; make sure materials are copyright approved or your own products.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss and demonstrate the procedures in the assignment and job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.
15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Invite a local ACR service company owner or representative to talk to the class about transitional or alternative refrigerants that are already being used in your service area. Ask the owner/rep to talk about any retrofits the company has performed and how the switch to a new lubricant was accomplished. Skill areas: **Foundation skills, listening**
2. If you have an automotive air conditioning program at your school, ask the instructor to talk to the class about its universal adoption by the automotive industry. Ask the instructor to show the class what a new 134a gauge looks like and compare a P/T chart with traditional refrigerants. Ask the instructor to comment on some of the problems the automotive industry is facing in retrofitting older automotive air conditioners with 134a. How are customers responding to the change? The idea of such a presentation would be to point out that changes in residential and commercial ACR will probably be similar to changes in the automotive industry. Skill areas: **Foundation skills, listening.**
3. Spend sufficient time on Objective 7 to really give students command of a pressure/temperature chart and how to use a chart for ACR service. Show both pressure and vacuum readings, and relate these readings to the manifold gauge set and how the gauges reflect pressure/temperature charts. Skill areas: **Basic skills, math and science.**
4. Demonstrate the proper use of a manifold gauge set as you prepare students for the ob sheets in this unit. Emphasize low-loss fittings and show students how they can and must comply with "de minimus" venting regulations in their training activities. Show the points on a typical system where the manifold gauge set can be effectively put to use. Skill areas: **Foundation skills, math and science.**

Resources Used in Developing This Unit

1. *Forane® Retrofit Training Guide*. Philadelphia, PA: Elf Atochem ATO, 1994.

Suggested Activities

2. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

3. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide*. Troy, MI: Business News Publishing Company, 1994, 1995.

4. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1. To purchase ASHRAE Standard 15, write:

   ASHRAE Publications Sales Department
   1791 Tullie Circle, NE
   Atlanta, GA 30329

2. For any of the SAE "J" standards that detail refrigerant handling, safety, and associated activities for the automotive industry, write:

   SAE
   Customer Service
   400 Commonwealth Drive
   Warrendale, PA 15096-0001

   Or call SAE at (412) 776-4970

3. The "Tech Digest" series from Elf Atochem details information about transitional and alternative refrigerants in use and under testing. For the series or for additional Forane® literature, training guides and case histories, call 1-800-343-7940.

4. For retrofit assistance from Elf Atochem, call the Retrofit Hotline at 1-800-RETRO 94 (1-900-738-7694).

5. For technical information about transitional and alternative refrigerants in use and under testing, write to AlliedSignal Chemicals for the *Genetron® Products Brochure*. Subtitled "Understanding Needs. Finding Solutions", the brochure presents technical reviews of several new refrigerants from AlliedSignal. Write:

   AlliedSignal Inc.
   Fluorocarbons
   PO Box 1053
   Morristwon, NJ 07962-1053

   Or call AlliedSignal at 1-800-631-8138.

Suggested Activities

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

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Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Answers to Assignment Sheet 1

Assignment Sheet 1

a. (4) 6.8
(5) 136.4

b. (4) 4.5
(5) 169.1
(6) 125

c. (4) 61.4
(5) 277.9 to 296.8

d. (4) 68.5
(5) 210.7 to 226.4

e. (4) 34.1
(5) 124.3

f. (4) 61.4
(5) 277.9 to 296.8

g. (4) 80.5
(5) 264.9

h. (4) 43.2
(5) 103.9

i. (4) 10.2
(5) 226.4

j. (4) 68.5
(5) 259.9 to 277.9

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Answers to Written Test

1. a. 6
   b. 9
   c. 11
   d. 1
   e. 7
   f. 10
   g. 3
   h. 8
   i. 4
   j. 2
   k. 5

2. a. transition
   b. CFCs
   c. low-ODP
   d. Some
   e. HFCs
   f. document compliance with
   g. "self-effectuating"

3. c, d, e, f, g

4. a. 5
   b. 3
   c. 1
   d. 4
   e. 2

5. a. (2)
   b. (2)

6. a. or there is not enough refrigerant in the system to make a determination.
   b. a virgin charge of refrigerant.
   c. the date of service, type of refrigerant, and amount of refrigerant used.

7. a, b, c, d

8. a. evaporator, condenser
   b. evacuation
   c. all phases

9. a. liquid
   b. the charge
   c. a leak

Answers to Written Test

10. c, d

11. a. B
    b. B
    c. D
    d. D
    e. B

12. a, b, d, e

13. a. (2) Alkaline
    (4) Polyolester
    b. traditional
    c. flushed from the system
    d. repeated
    e. AB
    f. Polyolester
    g. absorbing
    h. additives

14. a, b, d

15. a, c, e, f, g

16. a. (2)
    b. (3)

17. a. system operating pressures
    b. compound gauge, high-pressure
    c. right, red
    d. left, blue
    e. an equal
    f. yellow
    g. (1) pressures
    (2) liquid
    h. venting refrigerant to the atmosphere

18. Explanation must include the following minimum information:

    Unscrew the bezel on the face of the gauge, locate the adjustment screw and turn it so that the needle goes to zero.

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Written Test

Name ______________________________ Date ________________ Score ______

1. Match the terms on the right with their correct definitions. Definitions continue on next page.

______ a. A refrigerant blend that cannot be separated into its single components by distillation and which behaves as a single-component refrigerant in application and service

______ b. A mixture of two or more single-component refrigerants

______ c. A blend containing two single-component refrigerants

______ d. The temperature at which a blended refrigerant first starts to evaporate or the temperature where the first bubble of vapor appears at a constant temperature

______ e. The temperature point at which condensation begins to form in a system using a blended refrigerant

______ f. A change in composition as a blended refrigerant changes phases through evaporation and condensation, or changes because of a vapor leak

______ g. The tendency of a blended refrigerant to evaporate over a range of temperatures, specifically, the difference between bubble point and dew point

______ h. A refrigerant blend that can be separated into its single components by distillation, but exhibits performance characteristics very close to a single-component refrigerant; also called zeotrope

1. Bubble point
2. Ternary blend
3. Glide
4. Retrofit
5. Weakly flammable
6. Azeotrope
7. Dew point
8. NARM
9. Blend
10. Fractionation
11. Binary blend

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Written Test

_______i. Upgrading older equipment with the parts or refrigerant needed to make it perform like a new system, or making system changes which allow a transition or alternative refrigerant to replace a CFC or HCFC

_______j. A blend containing three single-component refrigerants

_______k. Able to burn, but not sustain a flame

2. Complete statements about problems and challenges for an industry in transition. Circle the material that best completes each of the following statements.

   a. Because of the EPA Clean Air Amendments of 1990, technicians face expanded responsibilities in handling three major types of refrigerants, the traditional refrigerants, the (**transition**) (**chlorine-free**) refrigerants, and the alternative refrigerants.

   b. One traditional refrigerant group is the (**CFCs**) (**HFCs**), and although production has stopped, these refrigerants will continue to be reclaimed and reused for years to come and provide technicians with valuable reference points for handling the transition and alternative refrigerants.

   c. The (**low-ODP**) (**medium-ODP**) HCFCs are another group of traditional refrigerants that will be slowly phased out while the industry develops alternative refrigerants with zero ODP.

   d. (**Some**) (**all**) transition and many alternative refrigerants have pressure/temperature relationships different from CFCs, and technicians will have to work with new pressure/temperature charts and other new reference materials when these refrigerants come into service.

   e. The (**HFCs**) (**HCFCs**) are the new alternative refrigerants of the future; technicians will quickly associate them with special lubricants and desiccants, "retrofitting" will become a frequent option.

   f. Handling refrigerants safely and keeping records will become specialized technician activities designed to (**document compliance with**) (**assure attention to**) EPA regulations.

   g. EPA regulations pose both problems and challenges, but the challenges are greater because the regulations are ("**self effectuating**") ("**nonpoliced**"), meaning that they have to be put into effect by the good faith applications of individual ACR technicians.

Written Test

3. Select true statements about the EPA SNAP program and its objectives. Place an "X" beside each true statement.

Note: For a statement to be true, all parts of the statement must be true.

______a. The Clean Air Act Amendments of 1990 do not require the EPA to evaluate new refrigerants, but the EPA does have general guidelines which manufacturers may adopt.

______b. The EPA program for refrigerant evaluation is called the Significant New Alternative Policy, better known as SNAP, and the only objective of the program is to make sure the alternative refrigerants have a zero ODP.

______c. Under the SNAP guidelines, independent testing groups work with the EPA to subject new substances to a variety of tests, including, but not limited to:

(1) Ozone depletion potential.

(2) Global warming potential.

(3) Flammability.

(4) Toxicity.

(5) Exposure potential.

(6) Economic and technical feasibility.

______d. As the EPA evaluates transition and new refrigerants, other agencies are looking at these refrigerants with a mind to protecting not just the environment, but system owners and the technicians who work with new substances.

______e. ASHRAE Standard 15 is specifically dedicated to improving the safety of technicians working on cooling systems, and it informs technicians about areas where technicians may experience danger and how to evaluate such circumstances.

______f. UL Guidelines 2154 directs its attention to planning for cost-effective retrofits and step-by-step guidelines for retrofitting systems large and small.

______g. The SAE J Standards cover retrofitting procedures and safety for all refrigerants used for automotive purposes.

Written Test

4. Match traditional refrigerants with their applications. Place the number beside the refrigerant designation in the blank beside a description of its applications.

______a. A popular CFC refrigerant for domestic refrigerators, freezers, and automobile air conditioners

______b. A popular HCFC refrigerant for residential and commercial air conditioners and freezers

______c. A popular CFC refrigerant for residential and commercial air conditioners, and dehumidifiers

______d. A popular HCFC refrigerant for commercial freezers and refrigerators

______e. A popular CFC refrigerant for low-pressure commercial and industrial air conditioners, particularly ones using centrifugal compressors

1. R-500
2. R-11
3. R-22
4. R-502
5. R-12

5. Solve problems about characteristics of blended refrigerants. Circle the number in front of the statement that best solves each of the following problems.

a. Some of your coworkers are discussing the old and new refrigerants, and one of them says the only difference is that the old refrigerants have ozone-depleting components in them. You know the statement creates a problem because:

(1) It fails to note that some transitional refrigerants also contain large amounts of ozone-depleting components.

(2) It needs to point out that old refrigerants are one component substances and that alternative and transitional refrigerants are binary blends containing two substances or trinary blends containing three substances, and they will have different P/T relationships.

Written Test

b. You are working on a system charged with a blended alternative refrigerant and you discover that it has leaked enough that it will require a significant charge of refrigerant to get back to normal. A coworker says you should repair the leak and charge the system again, but you know that poses a problem because:

(1) It will be very difficult to find the leak without evacuating the system.

(2) It would be easy to upset the balance of a blended refrigerant, so the remaining charge should be evacuated, returned for reclaiming, and the system should be recharged with virgin refrigerant.

(3) Recharging the system will require a P/T chart especially for the blended refrigerant.

6. Complete statements about how to avoid potential problems with refrigerants. Write in the missing information in each of the following statements.

a. You have just followed a routine to verify the type of refrigerant in the system, but the pressure/temperature chart in your final check does not indicate a specific refrigerant. This should tell you that the system probably contains a mixture

____

____

b. You are servicing a refrigeration system and cannot identify the refrigerant in the system. You know the system will have to be totally evacuated, the lubricant type will have to be verified, and service will have to start with

____

____

c. After going to the trouble of identifying an unknown refrigerant, the last thing you do after you evacuate and recharge the system is to assure that the next service technician won't have your problems. You will secure a tag to the system and the tag will show three things:

____

____

Written Test

7. Select true statements about gauges, charts, and pressure/temperature relationships. Place an "X" beside each true statement.

    _______a. Because a gas at a certain temperature will have a known pressure, gauges and charts that show pressure/temperature relationships have become valuable service tools.

    _______b. Many refrigerant manufacturers provide free pocket-size charts that a technician can quickly reference to relate a temperature reading to a corresponding pressure or a pressure reading to a corresponding temperature.

    _______c. Many compound gauges also show the pressure/temperature relationships of the three most popular traditional refrigerants, R-12, R-22, and R-502, and this permits a technician to read p/t relationships directly from the face of the gauge.

    _______d. Pressure/temperature charts and gauges for traditional refrigerants do not work with most transition or alternative refrigerants; however, manufacturers of replacement refrigerants publish new charts that are readily accessible, and gauge manufacturers already have a new gauge for the popular alternative refrigerant 134a.

    _______e. Gauges for traditional CFCs cannot be used with other refrigerants because the p/t relationships are different.

8. Compete statements about why pressure/temperature relationships are important. Circle the material that best completes each of the following statements.

    a. Pressure/temperature charts and gauges provide quick references to trouble spots in a system, particularly at the (**evaporator**) (**condenser**) where design suction pressure is a critical reference, and at the (**condenser**) (**evaporator**) where head pressure is a critical reference.

    b. The compound gauge set becomes extremely important when evacuating a system; under new EPA regulations, a system must be evacuated to specified levels when recovering refrigerant, and the vacuum readings from a compound gauge provide visual verification of proper (**evacuation**) (**pressure**) levels.

    c. P/T charts and gauges are valuable tools for (**all phases**) (**the pressure elements**) of ACR troubleshooting, and should make the move from traditional to alternative refrigerants an easy transition for technicians.

Written Test

9. Complete statements about charging a system with a blend. Write in the missing information in each of the following statements.

   a. In order for the components in blend to not separate, the blend has to be charged into the system as a ________________.

   b. After charging a system with a blend, the system should be tagged to alert later service technicians of the date of service, the type of refrigerant, and the total amount of ________________.

   c. When a service tag lists all the information it should, a technician servicing the system at a later date can quickly determine not only the kind of refrigerant, but if the system has ________________ that needs to be located.

10. Select true statements about "drop-in" and "retrofit" refrigerants. Place an "X" beside each true statement.

_____a. A refrigerant that is a direct one-on-one replacement for an existing CFC refrigerant is called a "retrofit" because it fits into place into a system without changing lubricants, desiccants, O-rings, hoses, or any other working parts.

_____b. The "retrofit" alternative is the ideal new refrigerant, but most new refrigerants are not one-on-one replacements because they require some modification to system components or system design.

_____c. HFC-134a has been adopted by the automotive industry as a replacement for R-12, and as of the 1995 model year, all major automobile manufacturers are using air conditioning systems with HFC-134a refrigerant in them.

_____d. HFC-134a, however, cannot be used as a "drop-in" replacement for R-12 in older automobile air conditioners because the 134a is not compatible with some lubricants used with the older systems, and O-rings and other components may have to be changed.

11. Differentiate between bubble point and dew point and what they mean. Place a "B" beside the following statements that apply to bubble point and a "D" beside statements that apply to dew point.

_____a. This is the point at which the first bubble of vapor appears at a constant temperature.

_____b. With other refrigerants this is known as the "boiling" point.

______c. A point that mirrors the saturated liquid phase of R-12 is also called this point.

______d. The temperature at which condensation first appears in the system is also called this point.

______e. This point will mirror the saturated vapor phase of R-12.

12. Select true statements about characteristics and applications of ACR lubricants. Place an "X" beside each true statement.

Note: For a statement to be true, all parts of the statement must be true.

______a. In all ACR systems that have a compressor, lubricants play two important roles:

(1) Lubricants protect against wear by forming a thin, hydrodynamic film that keeps mechanical surfaces separated and thus protected.

(2) Lubricants perform a sealing function by filling the gap between the piston and walls in a motor or compressor and help make the compression cycle more efficient.

______b. Some lubricants have antiwear (AW) compounds added as well as stabilizers, and undergo mechanical testing to determine the chemical interaction the lubricant has with the refrigerant and with metal surfaces.

______c. An oil must have a certain capacity to absorb or not absorb water, and this is known as the oil's affinity, or its ability to absorb water.

______d. Mineral oils absorb only a small amount of water, and any excess water in a system using mineral oil will be carried around the system where it could cause corrosion or even freeze.

______e. Some synthetic oils used in ACR applications are capable of holding much more water than mineral oil and they require special handling because of that characteristic.

Written Test

13. Complete statements about guidelines for adding or changing lubricant. Circle the material that best completes each of the following statements.

    a. Lubricants are usually referred to by their initials:

        (1) MO = Mineral Oil.

        (2) PAG = Poly (**Alkaline**) (**Acidized**) Glycol.

        (3) AB =Alkkylbenzene.

        (4) POE = (**Polylastomer**) (**Polyolester**).

    b. MO is the lubricant of choice for (**traditional**) (**transitional**) refrigerants, so adding or changing oil with R-12, R-22, R-500, and R-502 is just a matter of using the amount of MO recommended by the equipment manufacturer.

    c. MO is not miscible with most alternative and many transition refrigerants, and if it is present in a system being retrofitted, the MO may have to be (**flushed from the system**) (**diluted with AB**) before the system is charged with the new refrigerant.

    d. Always follow recommended flushing procedures when removing MO from a system because the complete procedure may require several hours and (**repeated**) (**two**) flushings to effect total MO removal.

    e. Most HCFC blends such as R-22 and R-502 will use the synthetic oil (**AB**) (**PAG**) because it can be mixed with up to 20% MO which will not require extensive flushing when converting a CFC/MO system to an HCFC blend.

    f. (**Polyolester**) (**AB**) oils are the oils of choice for alternative refrigerants because they are compatible with a wide range of alternative refrigerants.

    g. The PAG oils first used with R-134a applications posed problems with (**repelling**) (**absorbing**) water and separation, and in CFC applications, PAGs proved to be incompatible with chlorine, so the PAGs are under further evaluation.

    h. Always follow specifications of the compressor manufacturer when changing oil, and that includes the use of antiwear or other (**cleaners**) (**additives**) that may be specified.

Written Test

14. Select true statements about guidelines for working with synthetic oils. Place an "X" beside each true statement.

    ______a. Complete evacuation of the system before charging the system with oil.

    ______b. Do everything possible to avoid exposing synthetic oil to air because even the humidity in the air can affect performance.

    ______c. Use large oil containers instead of small ones.

    ______d. Keep oil containers capped at all times when not in use.

    ______e. Store containers of oil in warm areas.

15. Select true statements about desiccants, their characteristics and uses. Place an "X" beside each true statement.

    ______a. The function of a desiccant in an ACR system is to remove water that may have entered the system with the refrigerant or oil during charging, water that entered through hoses, or water that entered as part of air that entered the system while it was in vacuum.

    ______b. Desiccants may protect a system from rust and freezing, but they are pretty much confined to removing moisture from a system.

    ______c. Most desiccants used in ACR systems are molecular "sieve" type in-line driers that attract water molecules into molecular holes and electrically hold them there.

    ______d. Different refrigerants and oils have similar molecular sizes, so a desiccant that works well with a refrigerant usually works well with an oil.

    ______e. Selecting a drier with molecular holes that are too large will pick up more water, but it may also pick up undesirable substances too.

    ______f. The shape of a desiccant can also be important, and solid core or compacted bead-type sieves are recommended for retrofits, especially those switching to HFC-134a.

    ______g. For all desiccant service, original equipment or retrofit, follow the manufacturer's recommendations, and if problems are present, call a filter manufacturer direct to get help.

Written Test

16. Solve problems about refrigerant identification colors and numbers. Circle the number of the information that best solves each of the following problems.

    a. You are working with a coworker on a system that has to be serviced and charged with R-22. There is a green cylinder of refrigerant available, and your coworker says there is no doubt it is R-22 because R-22 always comes in a green cylinder. The problem is:

        (1) The refrigerant may have been taken from another system and you need to know if it is legal to put it back into the system you're working on.

        (2) Green is the traditional color for R-22 cylinders, but to be sure, look at the information silk-screened onto the cylinder; besides, there is other information there concerning safe use of the product.

        (3) The cylinder may not contain enough refrigerant to do the job and you need to weigh it first.

    b. You are working on a system that you know uses R-12 refrigerant, but the cylinder of refrigerant delivered to the job site has a 400 number on it. You should:

        (1) Read instructions carefully and use the refrigerant as directed.

        (2) Assume that the refrigerant was delivered because someone in authority has determined that it is right for that particular system.

        (3) Send the refrigerant back for the proper one. R-12 is a single component refrigerant and the 400 number definitely indicates a blend.

17. Complete statements about the manifold gauge set and its applications. Circle the material that best completes each of the following statements.

    a. The piece of equipment most often used in AC service is the manifold gauge set because it permits a technician to check (**system operating pressure**) (**refrigerant types**) quickly and effectively.

    b. The gauge set is built around a manifold with a center access and two gauges, a (**compound gauge**) (**dual-acting**) for measuring low-side pressure and vacuum, and a (**high-pressure**) (**calibrated**) gauge for measuring high-side pressure.

    c. The high-pressure gauge is always on the (**left**) (**right**), colored (**red**) (**blue**), and is used to measure only positive pressures up to 500 psi; no matter how the valves on the pressure gauge are set, the gauge will always measure whatever pressure source it is attached to.

d. The compound gauge is always on the (**left**) (**right**), colored (**blue**) (**red**), and used to measure both positive pressures up to 250 psi, and negative pressures, or vacuums from 0 in. hg (zero inches of mercury) to 30 in. hg; no matter how the valves on the compound gauge are set, the gauge will always measure whatever vacuum or pressure it is attached to.

e. The manifold portion of the manifold gauge set is divided into three pressure compartments so that opening either the low-side hand valve or the high-side hand valve will create (**a high**) (**an equal**) (**a low**) pressure in the center section.

f. Red and blue hoses are used to access the low- and high-side valves, and a (**yellow**) (**green**) hose is often used to attach to the center access on the manifold.

g. The capacity to control pressures in the gauge manifold by manipulating the low- and high-side valves gives the manifold gauge set wide-ranging applications such as:

(1) Checking system operating (**temperatures**) (**pressures**);

(2) Evacuating a system;

(3) Vapor or (**liquid**) (**pressure**) charging a system;

(4) Recovering vapor or vapor/liquid from a system.

h. Hoses used with manifold gauge sets should have low-loss fittings to help technicians comply in "good faith" with regulations that forbid (**venting refrigerant to the atmosphere**) (**using any other kind of fittings**).

18. Explain in your own words how to calibrate gauges on a manifold gauge set.

____

____

____

***Permission to duplicate this test is granted.**

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Compute Temperature/Pressure Relationships Rating ______

Comments: ______________________

____

Job Sheet 1—Attach a Manifold Gauge Set to Service Ports Rating ______

Comments: ______________________

____

Job Sheet 2—Pressure Check a Domestic Refrigeration System Rating ______

Comments: ______________________

____

Job Sheet 3—Pressure Check a Residential Air Conditioning System Rating ______

Comments: ______________________

____

Job Sheet 4—Pressure Check a Commercial Refrigeration System Rating ______

Comments: ______________________

____

Job Sheet 5—Determine the Type of Refrigerant in a Refrigeration or Air Conditioning System Rating ______

Comments: ______________________

____

Unit Evaluation Form

Other ____

____

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

633

*Permission to duplicate this form is granted.

Alternate Refrigerants Blends

Refrigerant	Manufacturer	ASHRAE#	Components	Application
FX 56	Elf Atochem	R-409A[2]	R-22/124/142b	R-12 Retroit
FX 10	Elf Atochem	R-408A[2]	R-125/143a/22	R-502 Retrofit
FX 70	Elf Atochem	R-404A	R-125/143a/134a	R-502 New/Retrofit
FX 220	Elf Atochem		R-23/32/134a	R-22 Alternative
AZ 50	Allied Signal	R-507[1]	R-125/143a	R-502 New/Retrofit
AZ 20	Allied Signal	R-410A[2]	R-32/125	R-22 Alternative
MP 39, 66	DuPont	R-401A,B	R-22/152a/124	R-12 Retrofit
HP 80, 81	DuPont	R-402A,B	R-125/290/22	R-502 Retrofit
HP 62	DuPont	R-404A	R-125/143a/134a	R-502 New/Retrofit
AC 9000	DuPont	R-407C[2]	R-32/125/134a	R-22 Alternative
(Klea) 60, 61	ICI	R-407A,B[1]	R-32/125/134a	R-502 New/Retrofit
(Klea) 66	ICI	R-407C[2]	R-32/125/134a	R-22 Alternative
(Isceaon) 69L	Rhone Poulenc	R-403B	R-290/22/218	R-502 Retrofit
GHG 12	Indianapolis Refrigeration Products	R-406A[1]	R-22/142b/600a	R-12 Retrofit
Greeencool 12	Gu/Greencool	R-405A[1]	R-22/152a/142b/C318	R-12 Retrofit
Greeencool 2018 A, B	Gu/Greencool	R-411A,B[2]	R-1270/22/152a	R-22 Service
OZ 12	OZ Technologies		R-290/600	R-12 Retrofit
HC 12A	OZ Technologies		Hydrocarbons	R-12 Service

CFC Refrigerants	HCFC Refrigerants	HFC Refrigerants	Hydrocarbon Refrigerants	Perfluorocarbon Refrigerants
R-11	R-22	R-32 R-143a	R-290 (propane)	R-218
R-12	R-123	R-125 R152a	R-600 (butane)	R-C318
R-115 *(51% in 502*	R-124	R-134a	R-600a (isobutane)	
with 49% 22)	R-142b		R-1270 (propylene)	

Courtesy Elf Atochem

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Information Sheet

1. **Terms and definitions**

   a. **Azeotrope** — A refrigerant blend that cannot be separated into its single components by distillation and which behaves as a single-component refrigerant in application and service

   b. **Blend** — A mixture of two or more single-component refrigerants

   c. **Binary blend** — A blend containing two single-component refrigerants

   d. **Bubble point** — The temperature at which a blended refrigerant first starts to evaporate or the temperature where the first bubble of vapor appears at a constant temperature

   e. **Dew point** — The temperature point at which condensation begins to form in a system using a blended refrigerant

   f. **Fractionation** — A change in composition as a blended refrigerant changes phases through evaporation and condensation, or changes because of a vapor leak

   g. **Glide** — The tendency of a blended refrigerant to evaporate over a range of temperatures, specifically, the difference between bubble point and dew point

   h. **NARM (Near-Azeotrope Refrigerant Mixture)** — A refrigerant blend that can be separated into its single components by distillation, but exhibits performance characteristics very close to a single-component refrigerant; also called zeotrope

   i. **Retrofit** — Upgrading older equipment with the parts or refrigerant needed to make it perform like a new system, or making system changes which allow a transition or alternative refrigerant to replace a CFC or HCFC

   j. **Ternary blend** — A blend containing three single-component refrigerants

   k. **Weakly flammable** — Able to burn, but not sustain a flame

2. **Problems and challenges for an industry in transition**

   a. Because of the EPA Clean Air Amendments of 1990, technicians face expanded responsibilities in handling three major types cf refrigerants, the traditional refrigerants, the transition refrigerants, and the alternative refrigerants.

Information Sheet

b. One traditional refrigerant group is the CFCs, and although production has stopped, these refrigerants will continue to be reclaimed and reused for years to come and provide technicians with valuable reference points for handling the transition and alternative refrigerants.

c. The low-ODP HCFCs are another group of traditional refrigerants that will be slowly phased out while the industry develops alternative refrigerants with zero ODP.

d. Some transition and many alternative refrigerants have pressure/temperature relationships different from CFCs, and technicians will have to work with new pressure/temperature charts and other new reference materials when these refrigerants come into service.

e. The HFCs are the new alternative refrigerants of the future; technicians will quickly associate them with special lubricants and desiccants, "retrofitting" will become a frequent option.

f. Handling refrigerants safely and keeping records will become specialized technician activities designed to document compliance with EPA regulations.

g. EPA regulations pose both problems and challenges, but the challenges are greater because the regulations are "self effectuating", meaning that they have to be put into effect by the good faith applications of individual ACR technicians.

3. The EPA SNAP program and its objectives

a. The Clean Air Act Amendments of 1990 require the EPA to evaluate new refrigerants that are proposed as replacements for the CFCs and HCFCs that are being phased out.

b. The EPA program for refrigerant evaluation is called the Significant New Alternative Policy, better known as SNAP, and the main objective of the program is to make sure the alternative refrigerants have a zero ODP and that they have merits which will make them safe and functional in the ACR marketplace.

c. Under the SNAP guidelines, independent testing groups work with the EPA to subject new substances to a variety of tests, including, but not limited to:

(1) Ozone depletion potential.

(2) Global warming potential.

(3) Flammability.

(4) Toxicity.

(5) Exposure potential.

(6) Economic and technical feasibility.

Information Sheet

d. As the EPA evaluates transition and new refrigerants, other agencies are looking at these refrigerants with a mind to protecting not just the environment, but system owners and the technicians who work with new substances.

e. ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) Standard 15 is specifically dedicated to improving the safety of technicians working on cooling systems, and it informs technicians about areas where technicians may experience danger and how to evaluate such circumstances.

f. UL (Underwriters Laboratories) Guideline 2154 directs its attention to planning for cost-effective retrofits and step-by-step guidelines for retrofitting systems large and small.

g. The SAE (Society of Automotive Engineers) J Standards cover retrofitting procedures and safety for all refrigerants used for automotive purposes.

4. Traditional refrigerants and their applications

a. **R-12** — A popular CFC refrigerant for domestic refrigerators, freezers, automobile air conditioners, and commercial refrigeration

b. **R-22** — A popular HCFC refrigerant for residential and commercial air conditioners and freezers

c. **R-500** — A CFC refrigerant used for some residential and commercial air conditioners, and dehumidifiers

d. **R-502**— A popular HCFC refrigerant for commercial freezers and refrigerators

e. **R-11** — A popular CFC refrigerant for low-pressure commercial and industrial air conditioners, particularly ones using centrifugal compressors

5. Characteristics of blended refrigerants

a. Traditional refrigerants have dependable performance characteristics because they are single-component refrigerants, meaning they contain only one molecule which serves to retain the refrigerant's integrity at all operating pressures and temperatures.

b. Some alternative refrigerants such as 134a are single component refrigerants, but most alternative and many transitional refrigerants are binary blends containing two substances, or ternary blends containing three substances.

c. Blends create special areas of concern for technicians because they are subject to varying amounts of "glide" and "fractionation."

Information Sheet

d. "Glide" is the tendency of a refrigerant blend to evaporate and condense over a range of temperatures instead of at a single temperature, and thus requiring attention to different methods of determining superheating and supercooling.

Note: Tests conducted by ICOR International, Inc. indicate that R-406A used to replace R-12 actually increases the capacity of the system, and that spreading out the area of evaporation and condensation only makes the equipment more efficient, so glide can be a very positive element in a refrigerant.

e. "Fractionation" is the tendency of a refrigerant blend to change in composition when there is a vapor leak in the system because that part of the blend with the highest pressure will leak out of the system at a faster rate than lower pressure components.

f. In general, blended refrigerants are not as dense as single-component refrigerants, and will require less refrigerant to fully charge a system.

Example: In literature about their R-406A transition refrigerant, ICOR International, Inc. recommends 80% of the charge the system would use with R-12. In other words, a system that uses 10 ounces of R-12 should require only 8 ounces of 406A.

g. Because of the potential for upsetting the balance of a blend, a system that has leaked should have the remaining charge recovered so it can be returned to the manufacturer for reclaiming, and a virgin charge should be used to recharge the system.

6. How to avoid potential problems with refrigerants

a. Before you service any ACR system, make sure you know what type of refrigerant the system contains.

b. If you are not certain what refrigerant the system contains, read the manufacturer's name plate and the compressor data plate, and write the information down so you can take it back to be filed for future reference.

c. If name plate information is incomplete, or if you suspect the system may have a different refrigerant in it, use the following routine:

(1) Turn the system off.

(2) Allow the high and low pressures to equalize.

(3) Check head pressure and suction pressure with a manifold gauge set.

(4) Compare high and low pressure to a p/t chart, and if they do not indicate a specific refrigerant, the system probably contains a mixture or there is not enough refrigerant in the system to make a determination.

Information Sheet

d. In service work, when you confront a system with an unknown refrigerant, check with a supervisor before completing service because chances are the system will have to be totally evacuated, lubricant will have to be verified, and service will have to start from scratch with a virgin charge.

e. **Do your paper work**; write down the date, location, and type of system you worked on, and especially **the type and amount of refrigerant used** because this will become a part of company records that must be maintained to meet EPA regulations.

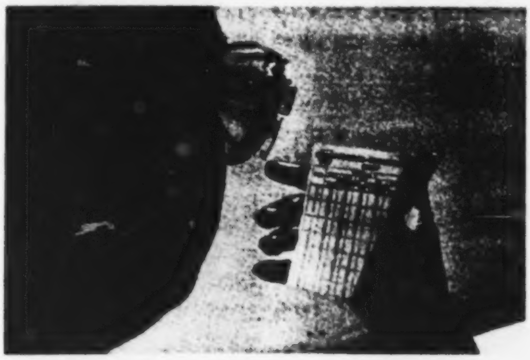
f. For the sake of service personnel that may service the same system at a later date, leave a tag in a secure place to indicate the last date of service and the type and amount of refrigerant used.

g. Some blends contain isobutane or propane that could make the refrigerant weakly flammable in the event of a significant leak, and "topping off" with a blend can also make the refrigerant weakly flammable, so avoid topping off.

7. Gauges, charts, and pressure/temperature relationships

a. Because a gas at a certain temperature will have a known pressure, gauges and charts that show pressure/temperature relationships have become valuable service tools.

b. Many refrigerant manufacturers provide free pocket-size charts that a technician can quickly reference to relate a temperature reading to a corresponding pressure or a pressure reading to a corresponding temperature.

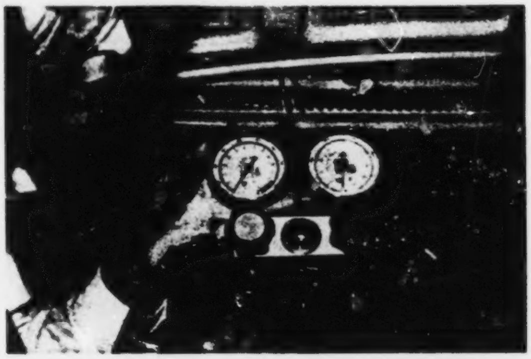


c. Many compound gauges also show the pressure/temperature relationships of the three most popular traditional refrigerants, R-12, R-22, and R-502, and this permits a technician to read p/t relationships directly from the face of the gauge.

Note: If you let the p/t chart in the truck or forgot it completely, the gauge will be your best friend, and if you forgot the chart and do not have a gauge with the R references on it, the worst thing you can do is trust to memory!

Information Sheet

d. Pressure/temperature charts and gauges for traditional refrigerants do not work with most transition or alternative refrigerants; however, manufacturers of replacement refrigerants publish new charts that are readily accessible, and gauge manufacturers already have a new gauge for the popular alternative refrigerant 134a.



e. Gauges for traditional CFCs can be used with other refrigerants as long as a p/t chart for the replacement refrigerant is available because the pressure reading will still reflect the pressure, or vacuum, of the refrigerant at a given point in the system.

8. Why pressure/temperature relationships are important

a. Pressure/temperature charts and gauges provide quick references to trouble spots in a system, particularly at the evaporator where design suction pressure is a critical reference, and at the condenser where head pressure is a critical reference.

Note: Head pressure divided by suction pressure equals compression ratio, a figure that is used to determine if a compressor is functioning properly.

b. The compound gauge set becomes extremely important when evacuating a system; under new EPA regulations, a system must be evacuated to specified levels when recovering refrigerant, and the vacuum readings from a compound gauge provide visual verification of proper (or improper) evacuation levels.

c. P/T charts and gauges are valuable tools for all phases of ACR troubleshooting, and should make the move from traditional to alternative refrigerants an easy transition for technicians.

Information Sheet

Vacuum—*Italic Figures*			Gauge Pressure—**Bold Figures**			Vacuum—*Italic Figures*			Gauge Pressure—**Bold Figures**		
TEMPERATURE		REFRIGERANT				TEMPERATURE		REFRIGERANT			
	CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixture)			CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixture)	
°F.	11	12	22	500	502	°F.	11	12	22	500	502
11	*22.9*	15.2	33.9	20.5	42.2	40	*15.6*	37.0	69.0	46.2	80.2
12	*22.7*	15.8	34.9	21.2	43.2	41	*15.3*	37.9	70.5	47.2	81.8
13	*22.5*	16.5	35.9	21.9	44.3	42	*15.0*	38.8	72.0	48.4	83.4
14	*22.3*	17.1	36.9	22.6	45.4	43	*14.7*	39.7	73.5	49.6	85.0
15	*22.0*	17.7	37.9	23.4	46.6	44	*14.3*	40.7	75.0	50.7	86.6
16	*21.9*	18.4	38.9	24.2	47.7	45	*13.9*	41.7	76.6	51.8	88.3
17	*21.7*	19.0	40.0	24.9	48.9	46	*13.5*	42.6	78.2	53.0	90.0
18	*21.5*	19.7	41.1	25.7	50.1	47	*13.2*	43.6	79.8	54.2	91.7
19	*21.3*	20.4	42.2	26.5	51.2	48	*12.8*	44.6	81.4	55.4	93.4
20	*21.1*	21.0	43.3	27.3	52.4	49	*12.5*	45.7	83.0	56.6	95.2
21	*20.9*	21.7	44.4	28.2	53.7	50	*12.0*	46.7	84.7	57.8	96.9
22	*20.6*	22.4	45.5	29.0	54.9	55	*10.0*	52.0	93.3	64.1	106.0
23	*20.4*	23.2	46.7	29.8	56.2	60	*7.7*	57.7	102.5	71.0	115.6
24	*20.2*	23.9	47.8	30.7	57.4	65	*5.3*	63.7	112.2	78.1	125.8
25	*20.0*	24.6	49.0	31.6	58.7	70	*2.6*	70.1	122.5	85.8	136.6
26	*19.7*	25.4	50.2	32.4	60.0	75	.4	76.9	133.4	93.9	148.0
27	*19.5*	26.1	51.5	33.3	61.4	80	1.6	84.1	145.0	102.5	159.9
28	*19.1*	26.9	52.7	34.3	62.7	85	3.2	91.7	157.2	111.5	172.5
29	*18.9*	27.7	54.0	35.2	64.1	90	5.0	99.7	170.1	121.2	185.8
30	*18.6*	28.5	55.2	36.1	65.4	95	6.8	108.2	183.7	131.3	199.8
31	*18.4*	29.3	56.5	37.0	66.8	100	8.9	117.1	197.9	141.9	214.4
32	*18.1*	30.1	57.8	38.0	68.2	105	11.1	126.5	212.9	153.1	229.8
33	*17.8*	30.9	29.2	39.0	69.7	110	13.4	136.4	228.7	164.9	245.8
34	*17.5*	31.7	60.5	409.0	71.1	115	15.8	146.7	245.3	177.4	262.7
35	*17.1*	32.6	61.9	41.0	72.6	120	18.5	157.6	262.6	190.3	280.3
36	*16.9*	33.4	63.3	42.0	74.1	125	21.2	169.0	280.7	204.0	298.7
37	*14.6*	34.3	64.4	43.1	75.6	130	24.3	181.0	299.3	218.2	318.0
38	*16.3*	35.2	66.1	44.1	77.1	135	27.4	193.5	316.6	232.1	338.1
39	*16.0*	36.1	67.5	45.2	78.6						

9. Charging a system with a blend

a. Refrigerant blends have to be liquid charged so the components will not separate.

b. Do not use automatic charging equipment to charge a system with a refrigerant blend; most of this equipment has a small, restricted opening that will not facilitate the denser blend, and the timing devices are generally related to the use of the original refrigerant.

Information Sheet

c. If the system requires retrofitting before charging, follow manufacturer's directions carefully to include lubricant flushing and replacement and desiccant, or drier, replacement as required.

d. After servicing a system with a replacement refrigerant, whether it is a retrofit or a drop-in replacement, tag the system so that the date of service, the name of the refrigerant, and the amount of the charge are all highly visible for technicians that will later maintain or service the equipment.

Service Alert

This system was serviced on ____________ by ____________.
The refrigerant was ____________. The charge was ____________.
Total system charge was ____________.

For service information call:
ABC Heating & Air (405) 777-7777

e. Service tags provide good public relations with customers and almost assure that the servicing company will be called the next time the system needs attention.

f. When a service tag properly lists total system charge and amount of added refrigerant, it also serves as a good way to quickly determine if the system has a slow leak that needs to be located.

10. "Drop-in" and "retrofit" refrigerants

a. A refrigerant that is a direct one-on-one replacement for an existing CFC refrigerant is called a "drop-in" because it can be placed into a system without changing lubricants, desiccants, O-rings, hoses, or any other working parts.

Note: As of this writing, there is only one true "drop-in" transition refrigerant, and that is R-406A made by ICOR International, Inc. R-406A was formulated by George Goble at Purdue University in 1989, and has had extensive field tests in all commercial refrigeration applications, ice machines, domestic refrigeration, and automobile and other transport refrigeration with no incidence of refrigerant-related failure.

b. The "drop-in" alternative is the ideal new refrigerant, but most alternate refrigerants are not one-on-one replacements because they require some modification to system components or system design.

Information Sheet

c. HFC-134a has been adopted by the automotive industry as a replacement for R-12, and as of the 1995 model year, all major automobile manufacturers are using air conditioning systems with HFC-134a refrigerant in them.

d. HFC-134a, however, cannot be used as a "drop-in" replacement for R-12 in older automobile air conditioners because the 134a is not compatible with some lubricants used with the older systems, and O-rings and other components may have to be changed.

Note: Major auto manufacturers do outline procedures for retrofitting old systems for 134a, but as long as R-12 is still available in sufficient quantities, it is very probably that older automotive air conditioners will not be retrofitted, although complete replacements with H-134a equipment are probably advisable for total system failures.

11. Bubble point and dew point and what they mean

a. When a single-component refrigerant starts to evaporate, it is said to have reached its boiling point, but with a blended refrigerant, this equivalent point is called the bubble point, the point at which the first bubble of vapor appears at a constant pressure.

b. The temperature at which condensation appears in a blended refrigerant is said to be its dew point.

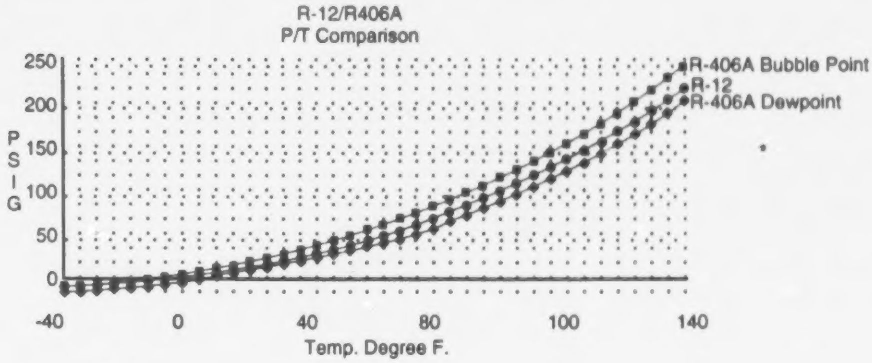
c. In the replacement refrigerant R-406A, the bubble point is about the same as the boiling point for R-12, the refrigerant that R-406A is designed to replace, and theoretically, the bubble point will mirror the saturated vapor phase readings of R-12.

d. With R-406A, the dew point is the temperature at which condensation first begins to form in the system, and theoretically, the dew point will mirror the saturated liquid phase of R-12.

Information Sheet

e. Since R-406A is an R-12 replacement, the bubble point and dew point should closely bracket the boiling point and condensation point of R-12.

Note: How close R-406A operating pressures/temperature mirror R-12 are well demonstrated in the following graph that shows how the "glide" in R-406A brackets the pressure/temps of R-12.



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f. It is also interesting to note that the head pressure in a system with R-406A will be lower than the system charged with R-12, a factor that contributes to less wear and tear on system components.

12. Characteristics and applications of ACR lubricants

a. In all ACR systems that have a compressor, lubricants play two important roles:

(1) Lubricants protect against wear by forming a thin, hydrodynamic film that keeps mechanical surfaces separated and thus protected.

(2) Lubricants perform a sealing function by filling the gap between the piston and walls in a motor or compressor and help make the compression cycle more efficient.

b. Some lubricants have antiwear (AW) compounds added as well as stabilizers, and undergo mechanical testing to determine the chemical interaction the lubricant has with the refrigerant and with metal surfaces.

Example: Mineral oil is used with CFC-12 because the chlorine in the refrigerant reacts chemically with metal surfaces to improve the lubrication capacity of the oil.

Information Sheet

c. An oil must have a certain capacity to absorb or not absorb water, and this is known as the oil's hygroscopicity, or affinity to absorb water.

d. Mineral oils absorb only a small amount of water, and any excess water in a system using mineral oil will be carried around the system where it could cause corrosion or even freeze.

e. Some synthetic oils used in ACR applications are capable of holding much more water than mineral oil and they require special handling because of that characteristic.

13. Guidelines for adding or changing lubricant

a. Lubricants are usually referred to by their initials:

(1) MO = Mineral Oil.

(2) PAG = Poly Alkaline Glycol.

(3) AB = Alkkylbenzene.

Example: Zerol 200 TD is a popular AB lubricant.

(4) POE = Polyolester.

Example: Mobile EAL Arctic 22 is a popular P.O.E. lubricant.

b. MO is the lubricant of choice for traditional refrigerants, so adding or changing oil with R-12, R-22, R-500, and R-502 is just a matter of using the amount of MO recommended by the equipment manufacturer.

c. MO is not miscible with most alternative and many transition refrigerants, and if it is present in a system being retrofitted, the MO may have to be flushed from the system before the system is charged with the new refrigerant.

d. Always follow recommended flushing procedures when removing MO from a system because the complete procedure may require several hours and repeated flushings to effect total MO removal.

e. Most HCFC blends such as R-22 and R-502 will use the synthetic oil AB because it can be mixed with up to 20% MO which will not require extensive flushing when converting a CFC/MO system to an HCFC blend.

f. Polyolester oils are the oils of choice for alternative refrigerants because they are compatible with a wide range of alternative refrigerants.

Information Sheet

g. The PAG oils first used with R-134a applications posed problems with absorbing water and separation, and in CFC applications, PAGs proved to be incompatible with chlorine, so the PAGs are under further evaluation.

h. Always follow specifications of the compressor manufacturer when changing oil, and that includes the use of antiwear or other additives that may be specified.

TABLE 1. LUBRICANT COMPATIBILITY

REFRIGERANT	M.O.	P.A.G	A.B.	P.O.E.
R-12	YES	NO	YES	YES
R-22	YES	NO	YES	YES
R-500	YES	NO	YES	YES
R-502	YES	NO	YES	YES
R-134a	NO	YES	NO	YES
R-404A(FX-70)	NO	NO	NO	YES
FX-56	YES	NO	YES	YES

*M.O. (Mineral Oil PAG (Poly Alkaline Glycol) A.B. (Alkylbenzene) POE (Polyolester)

Courtesy Elf Atochem from the *Forane© Retrofit Training Guide*

14. Guidelines for working with synthetic oils

a. Complete evacuation of the system before charging the system with oil.

b. Do everything possible to avoid exposing synthetic oil to air because even the humidity in the air can affect performance.

c. Use small oil containers instead of large ones.

d. Keep oil containers capped at all times when not in use.

e. Store containers of oil in areas that are as humidity-free as possible.

15. Desiccants, their characteristics and uses

a. The function of a desiccant in an ACR system is to remove water that may have entered the system with the refrigerant or oil during charging, water that entered through hoses, or water that entered as part of air that entered the system while it was in vacuum.

Information Sheet

b. Desiccants may protect a system from rust and freezing and are even capable of scavenging for acids to protect against corrosion.

c. Most desiccants used in ACR systems are molecular "sieve" type in-line driers that attract water molecules into molecular holes and electrically hold them there.

d. Different refrigerants and oils have different molecular sizes, so a desiccant that works well with a refrigerant and oil may not work well with another refrigerant/oil combination.

e. Selecting a drier with molecular holes that are too large will pick up more water, but it may also pick up undesirable substances too.

f. The shape of a desiccant can also be important, and solid core or compacted bead-type sieves are recommended for retrofits, especially those switching to HFC-134a.

g. For all desiccant service, original equipment or retrofit, follow the manufacturer's recommendations, and if problems are present, call a filter manufacturer direct to get help.

16. Refrigerant identification colors and numbers

a. System refrigerant requirements are usually listed on the data plate of the condensing unit; the information may be by name or number with the amount of charge listed in pounds and ounces.

b. Technicians can generally ID refrigerant by the color of the cylinder it comes in; the color codes for some of the traditional refrigerants are:

(1) R-11 — Orange

(2) R-12 — White

(3) R-22 — Green or light green

(4) R-500 — Yellow

(5) R-502 — Light purple

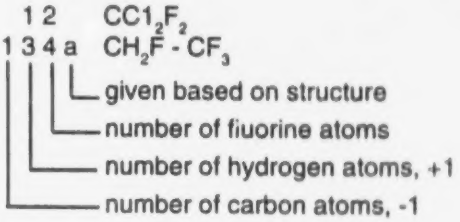
c. The color codes for other refrigerants may have significant variations in shade from one manufacturer, so while color provides a general reference, it's always best to rely on the information silk-screened on the cylinder.

d. EPA regulations require that information silk-screened onto a cylinder include the name and chemical composition of the product, safety requirements, and warnings about use or handling.

Information Sheet

e. MSDSs (material handling data sheets) and other technical information should be available on request from the manufacturer.

f. Refrigerant can also be identified by an R, standing for refrigerant, number in what is called the ASHRAE ID system.


12 $CC1_2F_2$
134a $CH_2F - CF_3$
given based on structure
number of fluorine atoms
number of hydrogen atoms, +1
number of carbon atoms, -1

Courtesy Elf Atochem

g. The 400- and 500-series numbers are reserved for blend identification; the 400-series are zetropes and the 500-series are azeotropes.

h. Even though the ASHRAE numbers have been around along time, the modern trend toward refrigerant ID is to list them by their basic chemical composition.

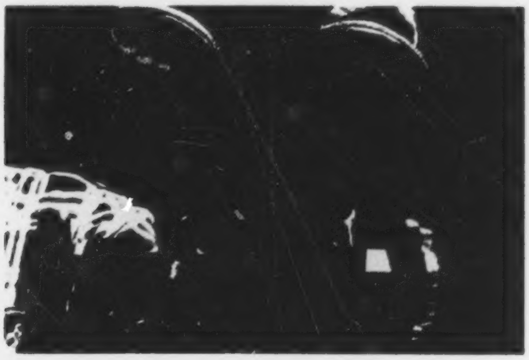
Example: R-12 becomes CFC-12, R-22 becomes HCFC-22, and R-134a becomes HFC-134a.

17. The manifold gauge set and its applications

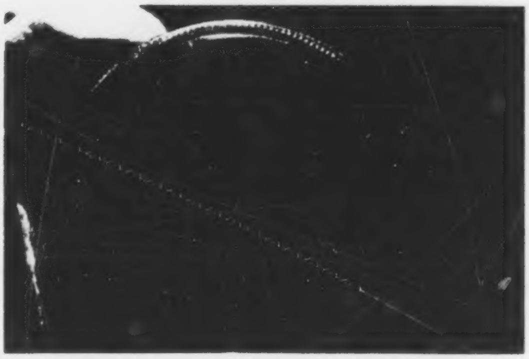
a. The piece of equipment most often used in AC service is the manifold gauge set because it permits a technician to check system operating pressure quickly and effectively.

Information Sheet

b. The gauge set is built around a manifold with a center access and two gauges, a compound gauge for measuring low-side pressure and vacuum, and a high-pressure gauge for measuring high-side pressure.

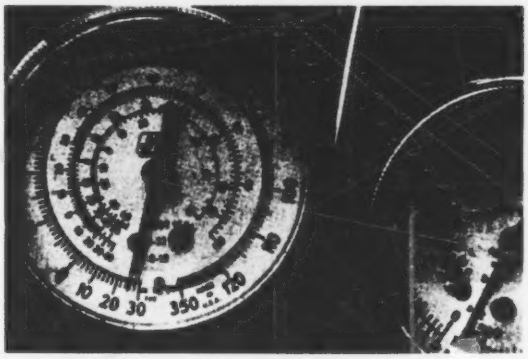


c. The high-pressure gauge is always on the right, colored red, and is used to measure only positive pressures up to 500 psi; no matter how the valves on the pressure gauge are set, the gauge will always measure whatever pressure source it is attached to.



Information Sheet

d. The compound gauge is always on the left, colored blue, and used to measure both positive pressures up to 250 psi, and negative pressures, or vacuums from 0 in. hg (zero inches of mercury) to 30 in. hg; no matter how the valves on the compound gauge are set, the gauge will always measure whatever vacuum or pressure it is attached to.



e. The manifold portion of the manifold gauge set is divided into three pressure compartments so that opening either the low-side hand valve or the high-side hand valve will create an equal pressure in the center section.

f. Red and blue hoses are used to access the low- and high-side valves, and a yellow hose is often used to attach to the center access on the manifold.

g. The capacity to control pressures in the gauge manifold by manipulating the low- and high-side valves gives the manifold gauge set wide-ranging applications such as:

(1) Checking system operating pressures;

(2) Evacuating a system;

(3) Vapor or liquid charging a system;

(4) Recovering vapor or vapor/liquid from a system.

h. Hoses used with manifold gauge sets should have low-loss fittings to help technicians comply in "good faith" with regulations that forbid venting refrigerant to the atmosphere.

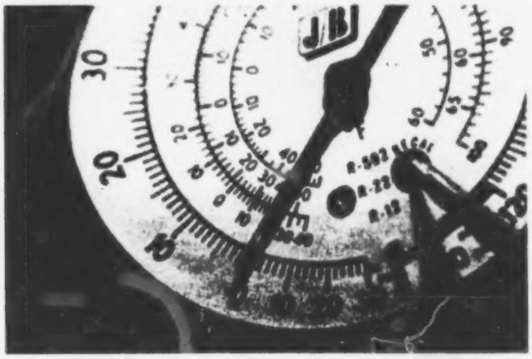
18. How to calibrate gauges on a manifold gauge set

a. The manifold gauge set is the technician's most valuable tool only when the gauges give true readings, and to assure this, the gauges need to be recalibrated if they do not return to zero when no pressure or vacuum is present.

Information Sheet

b. On most gauges, the bezel, the ring around the front cover, screws off to permit access to a small calibration screw usually located in the low right section of the gauge face.

c. Use a small, flat-blade screwdriver to move the screw left or right to get the gauge back to zero; in fact, the procedure is referred to as "zeroing" the gauge.



Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Student Supplement 1—Retrofit Checklist

The following checklist is typical of one that would be used when retrofitting to an alternative refrigerant. The procedure is from the Elf Atochem *Forane© Retrofit Training Guide* and is reprinted with permission.

1. Necessary Equipment

   — Recovery unit
   — Multi-refrigerant leak detector
   — Vacuum pump with fresh lubricant
   — Thermometer
   — Service manifold gauges
   — Safety equipment (safety glasses, gloves, etc.)
   — Waste oil container
   — Pressure/temperature charts
   — Baseline data from original system
   — Replacement filter driers
   — New lubricant
   — New refrigerant
   — Residual mineral oil test kit
   — New refrigerant and lubricant labels

2. Preparatory Work

   — Material compatibility check
   — Change mineral oil to new lubricant
   — Cycle new lubricant with CFC for at least 24 hours
   — Test mineral oil residual in new lubricant with a test kit
   — Verify residual M.O. content below recommended levels and system ready for retrofit

3. Post-retrofit Activities

   — Re-identify system with new refrigerant and lubricant
   — Leak test system
   — Performance check system

Refrigerants, Lubricants, and Desiccants Old and New
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Student Supplement 2—Lubricant Flushing Procedures

Mineral oil in an existing system usually has to be replaced with synthetic oil when one of the new alternative refrigerants is placed in the system. Requirements for flushing the M.O. out of the system will vary with the system undergoing retrofit, but the following suggestions should provide an idea of what the procedure should be and what it should accomplish.

Note: The following suggested procedures are adapted from the *Forane© Retrofit Training Guide* published by Elf Atochem and are reprinted with permission.

Flushing Procedures

Step 1: Remove the current charge of mineral oil from the system at all accessible oil removal locations. Prepare oil for later disposal per local codes.

Step 2: Replace M.O. with an equivalent charge of new lubricant. Although the M.O. and new refrigerant are not miscible, the new lubricant and the old refrigerant are.

Step 3: Operate the system for 24-48 hours to circulate the refrigerant and new lubricant throughout the system. The procedure returns the M.O. with the new lubricant, and the M.O. can be drained with the lubricant charge to facilitate removal of the remaining traces of M.O. from the system.

Step 4: Repeat Step 3 until the desired level of residual M.O. level is reached. Experience indicates that levels of 5% or less cause no noticeable operating problems, and can be reached after three flushes. In the following table, the percentage with the * sign indicates the starting level of M.O. remaining in a typical semi-hermetic system after initial flushing.

Flush #	50%*	40%*	30%*	20%*	10%*
1	25%	16%	9%	4%	1%
2	12.5%	6.4%	2.7%	.8%	.1%
3	6.25%	2.56%	.8%	.16%	.01%
4	3.1%	1.0%	.25%	.03%	0%

Final note: Suggested procedures have worked well for Elf Atochem applications, but any procedure that reduces residual M.O. levels to appropriate levels can be used. Always check with the O.E.M. for specific M.O. flushing procedures. Some oil flushing can be accomplished relatively quickly with quality recovery equipment.

Refrigerants, Lubricants, and Desiccants Old and New
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Student Supplement 3—Sample Retrofit Procedure

The following retrofit procedure for a hermetic reciprocating/scroll system changing from R-502 to Forane 404A (FX70) is from the Elf Atochem *Forane© Retrofit Training Guide* and is reprinted with permission.

Step 1: Gather baseline data from R-502 system to be used to optimize the system with FX-70 and polyester lubricant. Note the current R-502 charge, lubricant charge, existing operating temperatures and pressures, and overall system performance.

Step 2: Recover the existing R-502 charge using EPA approved recovery equipment and guidelines. Capture R-502 in an appropriate cylinder for disposition to a reclaiming facility.

Step 3: Remove existing M.O. from the system until it is reduced to a level of 5% or less. Use the flushing attachment of a typical recovery/claim machine, and circulate R-502 through the R/R system for approximately 30 minutes.

Step 4: Replace filter driers and examine sight glass for compatibility to new moisture indication levels necessary, 150 ppm. Because of the ability of new refrigerants to retain moisture, it is highly recommended that this step always be completed.

Step 5: Evacuate the system using a deep vacuum to at least 500 microns to insure that remaining traces of moisture have been removed.

Step 6: Charge compressor with proper polyester lubricant charge and Forane FX-70 refrigerant. Charge in the liquid phase only to avoid altering the original composition of the FX-70. The approximate FX-70 charge for most applications will be 85-90% of the original R-502 charge. It is not recommended to charge by visual indication through the sight glass because of the nature of the refrigerant and lubricant to appear "cloudy" in the liquid portion of the system, even at the proper charge.

Step 7: Place proper markings and identification on the system to indicate that the system has been retrofitted to FX-70 and polyester lubricant. Place the ID material in a highly visible location.

Step 8: Start the system and make final adjustments to achieve proper superheat settings. Normal operating pressures of FX-70 vary from 4-6% higher on the low side, and 8-10% higher on the high side of most typical applications.

Step 9: Consult the O.E.M. for any and all pressure relief modifications/requirements.

Refrigerants, Lubricants, and Desiccants Old and New
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Student Supplement 4—Performance Factors for a Blended Refrigerant

The following materials are adapted from Elf Atochem, ATO, *Tech Digest* for Forane FX-56, and are reprinted with permission.

Technical Data

Forane® FX-56: Basic Property Data

Chemical Formula:	R-22	$(CHClF_2)$ –60 wt.%
	R-124	(CF_3CHCl_2F) –25 wt.%
	R-142b	(CH_3CClF_2) –15wt.%
Average Molecular Weight:		97.45
Bubble Point @ 1 atm:		–29.6°F
Density of Saturated Liquid @ 80°F:		76.1 lb./cu. ft.
Density of Saturated Vapor @ b.p.:		0.306 lb./cu. ft.
Critical Temperature:		224.6°F
Critical Pressure:		652.5 psig
Saturated Liquid Pressure at 80°F:		106.2 psig
Latent Heat of Vaporization:		97.3 BTU/lb.
Specific Heat of Liquid @ 80°F:		0.535 BTU/lb. °F
Specific Heat of Vapor @ 1 atm:		0.336 BTU/lb. °F
Maximum Temperature Glide:		15.2°F
Flammability Limit:		non-flammable
Ozone Depletion Potential (ODP):		0.05
Halocarbon Greenhouse Warming Potential (HGWP):		0.3

Terms vital to FX-56 operational characteristics:

Bubble point is the temperature where the first bubble of vapor appears in liquid FX-56. This point is the **Saturated Liquid Temperature**.

Dew point is the temperature at which the last droplet of FX-56 evaporates and saturated gas exists. This point is the **Saturated Vapor Temperature**.

Fractionation is the change in composition of a refrigerant blend when it changes phase from liquid to vapor, evaporation, or from vapor to liquid, condensation.

Glide is the difference between the evaporator outlet and inlet due to fractionation of the blend.

Student Supplement 4

The following graphics demonstrate typical behavior of FX-56 in the evaporator:

Figure 1: FX-56 pressure-temperature graph

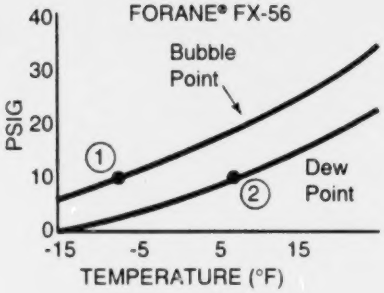
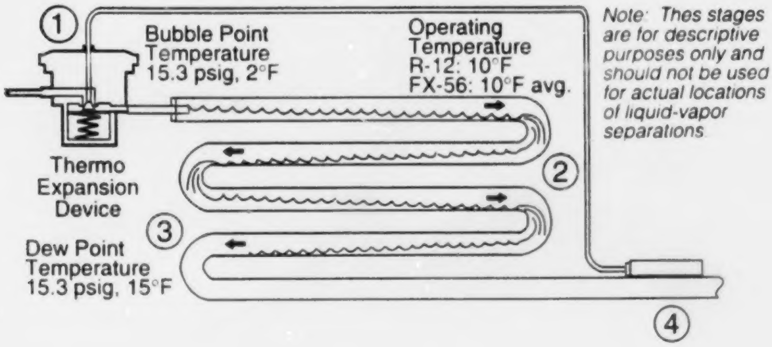


Figure 2: FX-56 fractionation in the evaporator. Bubble and Dew Point temperatures for FX-56 at 15.3 psig.


①
Bubble Point Temperature 15.3 psig, 2°F
Operating Temperature R-12: 10°F FX-56: 10°F avg.
Note: Thes stages are for descriptive purposes only and should not be used for actual locations of liquid-vapor separations
Thermo Expansion Device
②
③
Dew Point Temperature 15.3 psig, 15°F
④

At [1], before the expansion valve, FX-56 is at a saturated liquid state. For example, if the FX-56 pressure is at 15.3 psig, the FX-56 temperature is 2°F. This point is on the bubble pint line of the curve, the saturated liquid state.

At [2], as the temperature increases, FX-56 begins to evaporate. The vapor that first forms is more of the high-pressure component, R-22. As the vapor separates from the liquid, the remaining liquid shifts in composition toward the less volatile components, R-124 and R-142b. As the composition of the liquid (or vapor) changes, the Bubble Point temperature (or Dew Point temperature) of the remaining refrigerant changes as well, causing a temperature glide.

At [3], fractionation continues as the lesser volatile components, R-124 and R-142b, boil more rapidly along with the remaining R-22. For FX-56 at 15 psig, the temperature is 15°F.

At [4], FX-56 has completely evaporated and has returned to its original composition.

Student Supplement 4

Forane FX-56 Pressure Temperature Chart

Temp (°F)	Bubble (Liquid) Pressure (psig)	Dew (Vapor) Pressure (psig)	R-12 (psig)
−30	0.4	9.9	5.5
−25	1.9	6.8	2.3
−20	4.1	3.7	0.6
−15	6.5	0.2	2.4
−10	8.8	2.1	4.5
−5	11.7	4.3	6.7
0	14.5	6.5	9.2
5	17.9	9.3	11.8
10	21.3	12.0	14.6
15	25.3	15.3	17.7
20	29.4	18.5	21.0
25	34.1	22.3	24.6
30	38.8	26.1	28.4
35	44.1	30.6	32.6
40	49.5	35.0	37.0
45	55.5	40.2	41.7
50	61.6	45.4	46.7
55	68.6	50.6	52.0
60	75.6	55.7	57.7
65	83.5	63.4	63.8
70	91.4	71.1	70.2
75	100.1	78.9	77.0
80	108.8	86.7	84.2
85	118.9	95.6	91.8
90	128.9	104.3	99.8
95	139.9	114.3	108.3
100	151.0	124.1	117.2
105	163.0	135.2	126.6
110	175.0	146.3	136.4
115	188.4	158.7	146.8
120	201.8	171.1	157.7
125	216.7	182.0	169.1
130	231.6	198.9	181.0
135	247.7	214.0	193.5
140	263.9	229.1	206.6

Bold Numerals - Inches Hg. Below 1 ATM

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Assignment Sheet 1—Compute Temperature/Pressure Relationships

Name ______________________________ Overall Rating ____________

System operating temperatures include the low side T/P relationship at the evaporator and the high side T/P relationship at the condenser. Finding the low side P/T relationship requires no more than looking at a chart. Use the proper evaporator temperature, find the proper temperature and refrigerant on a P/T chart, and go straight across the P/T chart to find the pressure reading.

Example: An air conditioner using R-22 refrigerant has a temperature reading of 35°F at the evaporator. The pressure reading for R-22 at 35°F is 62 psig.

Finding the high side P/T relationship requires a reading at the liquid side of the condenser and a bit of simple addition. Measure the ambient temperature at the condenser, add 35° to get your condensing vapor temperature, then go straight across the P/T chart to find the pressure reading.

Example: A refrigerator using R-12 with an air-cooled condenser has condenser ambient reading of 85°F. Add 35° to get your condensing vapor temperature of 120°. Now, by going straight across the P/T chart we find that the pressure is 158 psig.

Easy? Sure it is, but there are some important variations. For instance, the example with R-12 identified an air-cooled condenser and a need to add 35° to the ambient reading. If it had been a water-cooled condenser, you would need to add only 20° to the ambient reading.

Now, about that basic 35° addition at the condenser. For refrigeration equipment, the rule is generally still true, but with the development of new, high-efficiency air-conditioning equipment, the standard has changed. While the older low-efficiency air conditioning equipment may require a 35° adjustment at the condenser, the new high-efficiency equipment may require as little as 20° adjustment. Along with the high-efficiency, there is medium-efficiency, and low-efficiency and they all have different temperature ranges at the condenser. Here's what it looks like in a chart:

Efficiency Rating	Temperature Range
High	20° - 25°
Medium	25° - 30°
Low	30° - 35°

You can usually differentiate between efficiency levels by looking at the size of the condenser relative to the unit (Btuh) capacity. Generally speaking, the larger the condenser coil, the higher the efficiency rating, and the lower the temperature range.

Assignment Sheet 1

Included with this assignment sheet are pressure temperature charts that cover all the refrigerants listed int he problems. Use the charts to determine the answers. All problems list a specific refrigerant. Some problems indicate the efficiency rating of the equipment. Note that your answer for some problems will be a range of temperatures, not a single temperature, and one problem will require you to determine how to work the same rules with a blended refrigerant.

a. Refrigerator

(1) Refrigerant R-12
(2) Evaporator –5°F
(3) Ambient 75°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

b. Freezer

(1) Refrigerant R-12
(2) Evaporator –10°F
(3) Ambient 90°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig
(6) Temperature of condensing Vapor ____________ °F

c. Air conditioner—Low efficiency

(1) Refrigerant R-22
(2) Evaporator 35°F
(3) Ambient 95°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

d. Air conditioner—High efficiency

(1) Refrigerant R-22
(2) Evaporator 40°F
(3) Ambient 85°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

e. Commercial refrigerator with water cooled condenser

(1) Refrigerant 134a
(2) Evaporator 40°F
(3) Ambient 80°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

Assignment Sheet 1

f. Air conditioner—Medium efficiency

(1) Refrigerant R-22
(2) Evaporator 35°F
(3) Ambient 100°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

g. Commercial freezer

(1) Refrigerant R-502
(2) Evaporator 40°F
(3) Ambient 80°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

h. Commercial refrigerator

(1) Refrigerant 406A
(2) Evaporator 40°F
(3) Ambient 65°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

i. Freezer

(1) Refrigerant R-22
(2) Evaporator –20°F
(3) Ambient 75°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

j. Air conditioner—High efficiency

(1) Refrigerant R-22
(2) Evaporator 40°F
(3) Ambient 100°F
(4) Low side pressure ____________ psig
(5) High side pressure ____________ psig

Assignment Sheet 1

Vacuum—*Italic Figures*		Gauge Pressure—**Bold Figures**				Vacuum—*Italic Figures*		Gauge Pressure—**Bold Figures**			
TEMPERATURE		REFRIGERANT				TEMPERATURE		REFRIGERANT			
	CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixture)			CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixture)	
°F.	11	12	22	500	502	°F.	11	12	22	500	502
11	*22.9*	15.2	33.9	20.5	42.2	40	*15.6*	37.0	69.0	46.2	80.2
12	*22.7*	15.8	34.9	21.2	43.2	41	*15.3*	37.9	70.5	47.2	81.8
13	*22.5*	16.5	35.9	21.9	44.3	42	*15.0*	38.8	72.0	48.4	83.4
14	*22.3*	17.1	36.9	22.6	45.4	43	*14.7*	39.7	73.5	49.6	85.0
15	*22.0*	17.7	37.9	23.4	46.6	44	*14.3*	40.7	75.0	50.7	86.6
16	*21.9*	18.4	38.9	24.2	47.7	45	*13.9*	41.7	76.6	51.8	88.3
17	*21.7*	19.0	40.0	24.9	48.9	46	*13.5*	42.6	78.2	53.0	90.0
18	*21.5*	19.7	41.1	25.7	50.1	47	*13.2*	43.6	79.8	54.2	91.7
19	*21.3*	20.4	42.2	26.5	51.2	48	*12.8*	44.6	81.4	55.4	93.4
20	*21.1*	21.0	43.3	27.3	52.4	49	*12.5*	45.7	83.0	56.6	95.2
21	*20.9*	21.7	44.4	28.2	53.7	50	*12.0*	46.7	84.7	57.8	96.9
22	*20.6*	22.4	45.5	29.0	54.9	55	*10.0*	52.0	93.3	64.1	106.0
23	*20.4*	23.2	46.7	29.8	56.2	60	*7.7*	57.7	102.5	71.0	115.6
24	*20.2*	23.9	47.8	30.7	57.4	65	*5.3*	63.7	112.2	78.1	125.8
25	*20.0*	24.6	49.0	31.6	58.7	70	*2.6*	70.1	122.5	85.8	136.6
26	*19.7*	25.4	50.2	32.4	60.0	75	.4	76.9	133.4	93.9	148.0
27	*19.5*	26.1	51.5	33.3	61.4	80	1.6	84.1	145.0	102.5	159.9
28	*19.1*	26.9	52.7	34.3	62.7	85	3.2	91.7	157.2	111.5	172.5
29	*18.9*	27.7	54.0	35.2	64.1	90	5.0	99.7	170.1	121.2	185.8
30	*18.6*	28.5	55.2	36.1	65.4	95	6.8	108.2	183.7	131.3	199.8
31	*18.4*	29.3	56.5	37.0	66.8	100	8.9	117.1	197.9	141.9	214.4
32	*18.1*	30.1	57.8	38.0	68.2	105	11.1	126.5	212.9	153.1	229.8
33	*17.8*	30.9	29.2	39.0	69.7	110	13.4	136.4	228.7	164.9	245.8
34	*17.5*	31.7	60.5	409.0	71.1	115	15.8	146.7	245.3	177.4	262.7
35	*17.1*	32.6	61.9	41.0	72.6	120	18.5	157.6	262.6	190.3	280.3
36	*16.9*	33.4	63.3	42.0	74.1	125	21.2	169.0	280.7	204.0	298.7
37	*14.6*	34.3	64.4	43.1	75.6	130	24.3	181.0	299.3	218.2	318.0
38	*16.3*	35.2	66.1	44.1	77.1	135	27.4	193.5	316.6	232.1	338.1
39	*16.0*	36.1	67.5	45.2	78.6						

Assignment Sheet 1

REFRIGERANT PRESSURE/TEMPERATURE CHART
VACUUM — ITALIC FIGURES — INCHES OF MERCURY
PRESSURE — BOLD FIGURES — PSIG

TEMP. F.	R-12	R-22	R-502	R-134A	R-406A BUBBLE	R-406A DEWPOINT
–40	*11.0*	0.5	4.1		*7.0*	*17*
–35	*8.4*	2.6	6.5		*5.8*	*15*
–30	*5.5*	4.9	9.2	*9.9*	*3.2*	*12.8*
–25	*2.3*	7.4	12.1	*6.9*	*1.9*	*10.4*
–20	0.6	10.2	15.3	*3.7*	2.3	*7.6*
–15	2.5	13.2	18.8	0.6	4.4	*4.6*
–10	4.5	16.4	22.6	1.9	6.7	*1.4*
–5	6.8	20.1	26.7	4.0	9.2	1.5
0	9.2	24.0	31.3	6.5	11.9	3.5
5	11.8	28.2	35.9	9.1	14.9	5.8
10	14.6	32.8	41.0	11.9	18.1	8.2
15	17.7	37.7	46.5	15.0	21.5	10.8
20	21.0	43.0	52.4	18.4	25.3	13.7
25	24.6	48.8	58.8	22.1	29.3	16.8
30	28.5	54.9	65.6	26.1	33.6	20.2
35	32.6	61.4	72.8	30.4	38.2	23.9
40	37.0	68.5	80.5	34.1	43.2	27.8
45	41.7	76.0	88.7	40.1	48.5	32.1
50	46.7	84.0	97.4	45.5	54.2	36.7
55	52.0	92.6	106.6	51.3	60.2	41.6
60	57.7	101.6	116.4	57.5	66.6	46.9
65	63.8	111.2	126.7	64.1	73.4	52.5
70	70.2	121.4	137.6	71.2	80.6	58.6
75	77.0	132.2	149.1	78.8	88.3	65.0
80	84.2	143.6	161.2	86.8	96.4	71.8
85	91.8	155.7	174.0	95.4	105.0	79.2
90	99.8	168.4	187.4	104.4	114.1	86.9
95	108.3	181.8	201.4	114.1	123.6	95.2
100	117.2	195.9	216.2	124.3	133.7	103.9
105	126.6	210.7	231.7	135.1	144.3	113.1
110	136.4	226.4	247.9	146.5	155.4	122.9
115	146.8	242.7	264.9	158.6	167.1	133.3
120	157.7	259.9	282.7	171.3	179.3	144.2
125	169.1	277.9	301.4	184.7	192.2	155.7
130	181.0	296.8	320.8	196.9	205.6	167.9
135	193.5	316.6	341.2	213.7	219.3	180.7
140	206.6	337.2	362.6	229.4	234.4	194.1

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Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Job Sheet 1—Attach a Manifold Gauge Set to Service Ports

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
All low-side connections and readings properly made	______
All high-side connections and readings properly made	______
"De minimus" venting effectively applied	______

A. Tools and materials

Refrigeration system(s) as selected by instructor
Manifold gauge set
Open end wrench, refrigerator service wrench, flat-blade screwdriver
Shop cloth
Temperature/pressure chart and thermometer
Safety glasses

B. Procedure 1 — Attach a manifold gauge set to stem-type service valves

> Note: This procedure with stem-type service valves and the following procedure with core-type service valves are routines that you will use repeatedly in the job sheets in this unit and the remaining units of this text. ACR service demands articulate knowledge and use of the manifold gauge set. Here's where you start!

☐ 1. Put on safety glasses.

☐ 2. Remove the valve stem covers and service port caps.

☐ 3. If a pressure switch capillary tube is connected to the service port, back seat the valve stem before removing the flare nut.

☐ 4. Clean around the gauge ports with a shop cloth.

☐ 5. Check to be sure the manifold gauge set valves are closed to center port.

Job Sheet 1

☐ 6. Check to see if pressure is present in the hoses and recover or release the refrigerant present.

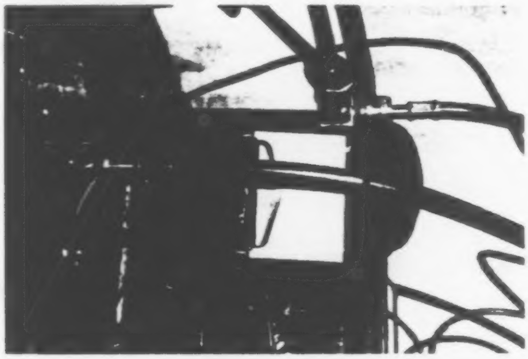
Note: There will almost always be minimal pressure in a hose. Venting the hose to atmosphere is okay; this is exactly what "de minimus" venting means.

☐ 7. Check the gauges to make sure they both read zero, and if they do not, remove the bezel and recalibrate as needed.

☐ 8. Screw the low-loss hose fitting from the left side, the compound gauge, of the manifold gauge set onto the suction line service valve port of the system.

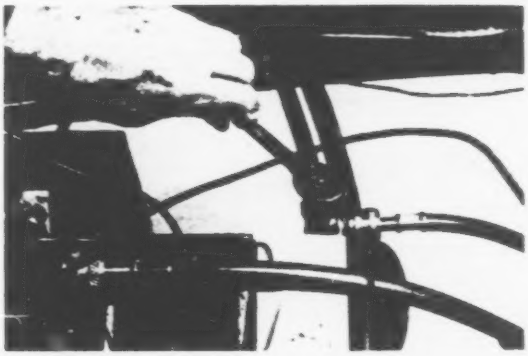
☐ 9. Screw the low-loss hose fitting from the right side, the high-pressure gauge, of the manifold gauge set onto the liquid line service valve port of the system.

Note: Specifications may sometimes call for hooking the high-pressure gauge to the discharge line service port.



☐ 10. Place a couple of drops of oil on the valve stems at the packing nut.

☐ 11. Crack each service valve stem by turning the stem one to two turns clockwise.



Job Sheet 1

☐ 12. Purge hoses at the manifold gauge set connections.

Note: This is another situation where "de minimus" venting is okay.

☐ 13. Start the system and allow system pressures to stabilize.

☐ 14. Operate the system for at least 30 minutes prior to recording any readings.

☐ 15. If the high-side gauge needle pulsates excessively, backseat the service valve stem until the vibration stops.

☐ 16. Check pressure readings.

☐ 17. Back seat the service valves.

☐ 18. Open the manifold gauge set valves to release hose pressure.

☐ 19 . Remove the manifold gauge set hoses from the service ports.

☐ 20. Secure the ends of the hoses on the manifold gauge set.

☐ 21. Rplace the service port caps and retighten them.

☐ 22. If pressure swtiches are connected to the service valve ports, the valve stems will have to be cracked during normal operation.

☐ 23. Check the service valve packing nuts for leaks, and tighten the packing nuts as required.

☐ 24. Replace the valve stem caps.

☐ 25 . Turn the system off and secure all equipment.

☐ 26. Have your instructor evaluate your manifold gauge set attachment to stem-type service valves.

C. Procedure 2 — Attach a manifold gauge set to core-type service valves

☐ 27. Put on safety glasses.

☐ 28. Remove the gauge port caps.

☐ 29. Clean around the gauge ports with a shop cloth.

☐ 30. Check to be sure the manifold gauge set valves are closed to center port.

Job Sheet 1

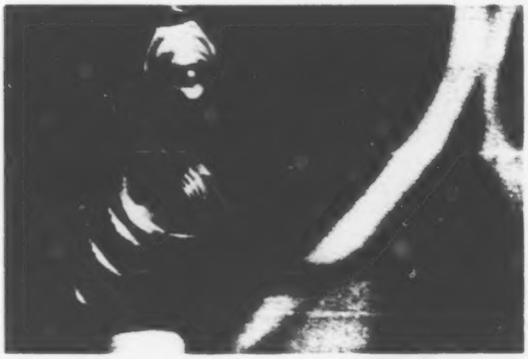
☐ 31. Check to see if pressure is present in the hoses and recover or release the refrigerant present.

Note: "De minimus" venting during a service procedure is permitted.

☐ 32. Check the gauges to make sure they both read zero, and if they do not, remove the bezel and recalibrate as needed.

☐ 33. Screw the low-loss fitting from the left side, the compound gauge, of the manifold set onto the suction line gauge port.

Note: The core depressor in the hose fitting will push on the core in the gauge port and open the hose to system pressure; also, if the hose has a low-loss fitting, the gauge port will push on the fitting valve and open it at the same time.



☐ 34. Screw the low-loss fitting from the right side, the high-pressure gauge, of the manifold gauge set onto the liquid line gauge port, or if specified, onto the discharge line gauge port.

☐ 35. Purge hoses at the manifold gauge set connections.

☐ 36. Start the system and allow system pressures to stabilize.

☐ 37. Operate the system for at least 30 minutes prior to recording any readings.

☐ 38. Check pressure readings.

☐ 39. Open the manifold gauge set valves to release hose pressure.

☐ 40. Using a rag, remove the manifold gauge set hoses form the gauge ports.

☐ 41. Secure the ends of the hoses onto the manifold gauge set.

Job Sheet 1

☐ 42. Replace the gauge port caps.

☐ 43. Turn the system off and secure all euqipment.

☐ 44. Have your instructor evaluate your manifold gauge set attachment to gauge ports.

☐ 45 . Clean up area and return tools and equipment to proper storage.

Evaluator's comments: ____

____

____

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Job Sheet 2—Pressure Check a Refrigeration System

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
All pressure readings properly made	_____
All temperature readings properly made	_____
"De minimus venting" regulation effectively applied	_____

A. Tools and materials

Small refrigeration system as selected by instructor
Manifold gauge set
Open end wrench and refrigerator service wrench
Shop cloth
Temperature/pressure chart and thermometer
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Attach a manifold gauge set to the high and low pressure ports; these are normally on the suction line and on the liquid line.

☐ 3. Operate the system you will be working on for at least 30 minutes prior to taking readings for this activity.

☐ 4. Locate the data plate; it should be on the door behind the kick plate, inside the cabinet on the lower left hand side, or on the condenser.

☐ 5. Record manufacturer's name and model number: ____________________

☐ 6. Record type of refrigerant: ______________________________

☐ 7. Check and record temperature of air or water entering the evaporator:
____

Job Sheet 2

☐ 8. Check and record temperature of air or water exiting the evaporator: ______________________________

☐ 9. Check and record temperature of air or water entering the condenser: ______________________________

☐ 10. Check and record temperature of air or water exiting the condenser: ______________________________

☐ 11. Read and record low side pressure: ____________________

☐ 12. Read and record high side pressure: ____________________

☐ 13. Have your instructor evaluate your pressure check.

☐ 14. Remove the manifold gauge set, and place a shop cloth around fittings and service ports when you disconnect hoses.

☐ 15. Replace low side and high side service port caps quarter of a turn with a wrench.

☐ 16. Secure all equipment, clean up area and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Job Sheet 3—Pressure Check an Air Conditioner

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
All pressure readings properly made	______
All temperature readings properly made	______
"De minimus venting" regulation effectively applied	______

A. Tools and materials

Air conditioner as selected by instructor
Manifold gauge set
Open end wrench and refrigerator service wrench
Shop cloth
Temperature/pressure chart and thermometer
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Attach a manifold gauge set to the high and low side pressure ports; these are normally at the suction line and the liquid line.

☐ 3. Operate the sytem you will be working on for at least 30 minutes prior to taking readings for this activity.

☐ 4. Locate the data plate; on a window air conditioner, it should be behind the front grill, and on a central air conditioning unit, it should be on the side of the condensing unit close to the removable panel.

☐ 5. Record manufacturer's name and model number: ______________

☐ 6. Record type of refrigerant: ______________

☐ 7. Check and record temperature of air entering the evaporator (return air):

____

Job Sheet 3

☐ 8. Check and record temperature of air exiting the evaporator (supply air): ______

☐ 9. Check and record temperature of air entering the condenser: ______

☐ 10. Check and record temperature of air exiting the condenser: ______

☐ 11. Record the low side pressure: ______

☐ 12. Record the high side pressure: ______

☐ 13. Have your instructor evaluate your pressure check.

☐ 14. Remove the manifold gauge set, and place a shop cloth around fittings and service ports when you disconnect hoses.

☐ 15. Secure all equipment, clean up area and return tools and materials to proper storage.

Evaluator's comments: ______

______

______

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Job Sheet 4—Pressure Check a Commercial Refrigeration System

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
All pressure readings properly made	______
All temperature readings properly made	______
"De minimus venting" regulation effectively applied	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set
Open end wrench and refrigerator service wrench
Shop cloth
Temperature/pressure chart and thermometer
Safety glasses

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Attach a manifold gauge set to the high and low pressure ports; these are normally on the suction line and on the liquid line.

☐ 3. Operate the system you will be working on for at least 30 minutes prior to taking readings for this activity.

☐ 4. Locate the data plate.

☐ 5. Record manufacturer's name and model number: ____________________

☐ 6. Record type of refrigerant: ____________________

☐ 7. Check and record temperature of air or water entering the evaporator: ____________________

Job Sheet 4

☐ 8. Check and record temperature of air or water exiting the evaporator: ____________________

☐ 9. Check and record temperature of air or water entering the condenser: ____________________

☐ 10. Check and record temperature of air or water exiting the condenser: ____________________

☐ 11. Read and record low side pressure: ____________________

☐ 12. Read and record high side pressure: ____________________

☐ 13. Have your instructor evaluate your pressure check.

☐ 14. Remove the manifold gauge set, and place a shop cloth around fittings and service ports when you disconnect hoses.

☐ 15. Replace low side and high side service port caps quarter of a turn with a wrench.

☐ 16. Secure all equipment, clean up area and return tools and materials to proper storage.

Evaluator's comments: ____________________

____

____

Refrigerants, Lubricants, and Desiccants Old and New
Unit 14

Job Sheet 5—Determine Type of Refrigerant in a Refrigeration or Air Conditioning System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
All data plate information recorded	______
Temperature/pressure readings properly made	______
Proper T/P Chart referenced	______
Refrigerant type identified and verified	______

A. Tools and materials

Refrigeration systems as selected by instructor
(May be one or three separate units)
Manifold gauge set
Open end wrench and refrigerator service wrench
Temperature/pressure chart and thermometer
Technician's mirror and shop cloth
Safety glasses

B. Procedure 1 — Identifying refrigerant type

☐ 1. Put on safety glasses.

☐ 2. Locate the unit's data plate and record the brand name and model number: ______________________

☐ 3. Record manufacturer's specified refrigerant type: ______________

☐ 4. Remove the inspection panel or case and locate the compressor data plate, which should be on top of the compressor, but you may have to use a mirror if the plate is on the inside.

Job Sheet 5

☐ 5. Record the brand anme and model number of of the unit: ____________

____

☐ 6. Record manufacturer's specified refrigerant type: ____________________

☐ 7. Locate the flow control which should be an expansion valve at the evaporator inlet, a liquid line valve on the liquid line, or a valve on any of the lines.

Note: If the system has a capillary tube for flow control, you will not find a refrigerant type specified on it.

☐ 8. Record the brand name and model number of of the unit: ____________

____

☐ 9. Record manufacturer's specified refrigerant type: ____________________

☐ 10. Have your instructor evaluate your findings.

C. Proceudre 2 — Verifying refrigerant type

☐ 11. Attach manifold gauge set to the high and low pressure ports; these are normally on the suction line and on the liquid line.

☐ 12. Record low and high side pressure readings:

Low side: ______________

High side: ______________

☐ 13. Check the ambient temperature around the system and compare your P/T readings with those on an appropriate P/T chart to help you evaluate what type of refrigerant is likely to be used in this type of equipment.

☐ 14. If pressures and temperatures correspond with those of a likely refrigerant on a P/T chart, this is probably the refrigerant in the system.

☐ 15. If pressures and temperatures do not match any likely refrigerant on a P/T chart, there are probably refrigerants mixed in the system or the system does not have enough refrigerant present for any of it to be in a liquid state.

Note: Both liquid and vapor must be present in a system for P/T readings to match those on a P/T chart; therefore, you cannot determine the type of refrigerant in the system if you have a condition as presented in Step 15.

Job Sheet 5

☐ 16. Have your instructor evaluate your refrigerant determination procedure.

Evaluator's comments: ____

____

____

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Objective Sheet

Unit Objective

After completing this unit, the student should be able to recover refrigerant with a hand-operated pump and with a recovery machine, and recover/recycle refrigerant with a recovery/recycling machine. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to refrigerant recovery, recycling, and reclaiming with their correct definitions.
2. Complete statements about general requirements for recovery, recycling, and reclaiming.
3. Differentiate between self-contained and system-dependent recovery.
4. Select true statements about recovery and recycling safety.
5. Complete statements about ARI Standard 700 and its applications.
6. Complete statements about guidelines for using DOT 39 disposable refrigerant cylinders.
7. Solve problems about guidelines for using refillable refrigerant cylinders.
8. Select true statements about basic recovery devices.
9. Complete statements about basic recovery processes.

Objective Sheet

10. Solve problems about EPA required evacuation practices during recovery.
11. Select true statements about special considerations for disposing of small appliances.
12. Solve problems about recycling equipment and processes.
13. Select true statements about the reclaiming process.
14. Solve problems about guidelines for effective recovery.
15. Solve problems about improperly mixed refrigerants and how to avoid them.
16. Solve problems about recovery system characteristics and applications.
17. Solve problems about recovery/recycling system characteristics and applications.
18. Select true statements about how to make an in-line filter.
19. Use a hand-operated pump to recover refrigerant from a small AC or refrigeration system. (Job Sheet 1)
20. Use a recovery machine to recover refrigerant from an AC or refrigeration system (Job Sheet 2)
21. Use a recovery/recycling machine to recover/recycle refrigerant from an AC or refrigeration system. (Job Sheet 3)

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add visual enhancement by making transparencies from materials that apply to the subject areas; make sure materials are copyright approved or your own products.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss and demonstrate the procedures in the assignment and job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. Invite a local ACR service company owner or representative to talk to the class about recovery and recycling or recovery/recycling equipment they are using on local service calls. Ask them specifically to address service problems and give the students tips on how best to conduct recovery and recycling at the job site. Ask your guest for a demonstration of a recovery process or a recovery/recycling process, and have a system available for the rep to work with. Also, ask the rep to discuss the EPA evacuation levels presented in Objective 10. Skill areas: **Foundation skills, math and science.**

2. Have cylinders available to demonstrate when you discuss Objective 6. Impress upon students the safety elements of handling cylinders properly. Show them how to disable a disposable cylinder so that it can't be used again. Skill areas: **Foundation skills, listening.**

3. Use Objective 3 to demonstrate recovery with a hand-operated pump, and tie it in with the procedures in Job Sheet 1. This will help students appreciate the real basics of the recovery process. Skill areas: **Foundation skills, math and science.**

4. Check with authorities about local laws concerning the removal of refrigerant from small appliances being discarded. Call the local land fill and find out what they tell people who show up with appliances not tagged as having had the refrigerant removed. This will give Objective 11 local significance.. Skill areas: **Communication skills, listening.**

5. Beginning with this unit, the job sheets each contain a Service Work Order so students can treat the job sheets as typical service activities that require documentation. These forms may be considered optional, but unless you have similar forms to document service, have students use these. Skill areas: **Learning skills, learning to learn.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

Suggested Activities

2. *Part II Environmental Protection Agency, 40 CFR Part 82, Protection of Stratospheric Ozone; Refrigerant Recycling; Final Rule.* Washington, DC: Environmental Protection Agency, 1993.

3. *Refrigerant Containment Applicant Study Guide.* Arlington, TX: Video General, Inc., 1994.

4. *Refrigerant Transition and Recovery Certification Program for HVAC/R Technicians.* Washington, DC: Air Conditioning Contractors of America, 1994.

5. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1994, 1995.

6. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

The *Federal Register* of Friday, May 14, 1993, contains Part II of 40 CFR and covers the intricate details of recovery, recycling, and reclaiming, including Table 1 concerning recovery levels, and Table 2 which shows standards for recovery and recycling equipment. Because it does detail many regulations that affect routine ACR service, it is a vital reference for instructors. For ordering information, contact the Stratospheric Ozone Information hotline at 1-800-296-1996.

Much of the information noted above is available in a fact sheet available from the Hotline. Titled "Stratospheric Ozone Protection Final Summary", the fact sheet summarizes in 11 pages an otherwise long document that is difficult to read. This is short enough that it can be copied for distribution to students. To order, call the Stratospheric Ozone Information Hotline at 1-800-296-1996.

Another Stratospheric Ozone Protection Fact Sheet contains "Background Information on EPA Approval of Certifiers of Refrigerant and Recovery Equipment." This one-page document is also available from the Stratospheric Ozone Information Hotline at 1-800-296-1996.

Certified Commercial Refrigerant Recovery/Recycling Equipment Directory is a helpful booklet published by Underwriters Laboratories Inc. The materials provide technical insight into the performance areas used to evaluate equipment designed for use in the refrigerant recovery/recycling processes. For information or to order, write:

Underwriters Laboratories, Inc.
333 Pingsten Road
Northbrook, IL 60062-2096

Or call UL at (708) 272-8800.

Suggested Activities

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Refrigerant Recovery, Recycling, and Reclaiming
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Answers to Written Test

1. a. 4
   b. 7
   c. 1
   d. 6
   e. 2
   f. 3
   g. 5

2. a, b, e, f, g

3. a. self-contained
   b. Self-contained
   c. liquid receiver
   d. recovery rates
   e. applicable requirements

4. a, e, f

5. a. purity
   b. compressor
   c. water
   d. quality
   e. not recommended

6. a. "Dot 39" cylinders
   b. zero
   c. heat
   d. 5 years

7. a, b, c, e, f

8. a. (2)
   b. (3)

9. a. (2)
   b. (2)

10. a. (2)
    b. (2)

11. a, b, d, e, f

12. a, c, e

Answers to Written Test

13. a. 700
    b. bank, certified
    c. destroyed
    d. paperwork

14. a, b, c, d, f, h

15. a. totally clean
    b. (1) Oil
       (2) filters

16. b, e, f, h

17. a, b, d, e, f, g

18. a. filter
    b. fed back into the system (or returned to the system)

Refrigerant Recovery, Recycling, and Reclaiming
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Written Test

Name ______________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions.

______a. The accidental or purposeful mixing of one refrigerant type with a different refrigerant type within a system, recovery device, or recovery cylinder

______b. To reprocess refrigerant to new product specifications by means which may include distillation; chemical analysis of the product is required to determine that appropriate product specifications are met; the term usually implies the use of processes or procedures available only at a reprocessing or manufacturing facility

______c. To remove refrigerant in any condition from a system and store it in a container without necessarily testing it or processing it in any way

______d. To reduce contaminants in used refrigerant by oil separation and single or multiple passes through devices which remove moisture, acidity, and particulate matter, such as replaceable core filter driers; the term usually applies to procedures implemented at the field job site or at a local service shop

______e. To return recovered, recycled, or reclaimed refrigerant to an operational system

______f. Products that are fully manufactured in a factory where they are charged and hermetically sealed with five pounds or less of refrigerant

______g. Brand new refrigerant that has never been used, recovered, recycled, or reclaimed

1. Recovery
2. Reuse
3. Small appliances
4. Improperly mixed refrigerant
5. Virgin refrigerant
6. Recycling
7. Reclaiming

Written Test

2. Select true statements about general recovery, recycling, and reclaiming requirements. Place an "X" beside each true statement.

______a. In the days before EPA "no venting" regulations, servicing an ACR system usually meant opening a service valve and venting refrigerant into the atmosphere, but this process is now illegal.

______b. Former recovery processes sometimes called for saving system refrigerant, but under new guidelines "saving refrigerant" is not optional, it must be done even if the amount of refrigerant removed is minimal.

______c. Recovery must also include evacuation to a level the technicians feels is sufficient.

______d. The most frequently used process is to recover refrigerant, service the system, and then charge the system with virgin refrigerant.

______e. In cases where recovered refrigerant may evidence contamination, the recovered refrigerant can be recycled on-site for immediate reuse or recycled at a local shop and reused at a later date in the same owner's equipment.

______f. In cases where recovered refrigerant is badly contaminated, the refrigerant can be shipped to an off-site reclaiming center for processing and cleaning to meet ARI 700 quality standards.

______g. In cases where recovered refrigerant is so badly contaminated that it cannot be cleaned, it should be shipped to an off-site reclaiming center to be destroyed.

3. Complete statements about EPA recovery methods and certification. Circle the material that best completes each of the following statements.

   a. The EPA defines two recovery methods that affect how much of a system charge must be evacuated from a small appliance; those methods are (**non-dependent**) (**self-contained**) and system-dependent.

   b. (**Non-contained**) (**Self-contained**) recovery is made without the aid of the compressor in a system, usually entails the use of a recovery/recycling machine, and is the most common method of recovering refrigerant.

   c. System-dependent recovery is made with the help of a system compressor and refrigerant may be collected in the (**liquid receiver**) (**evaporator**) of the system itself, or in a refillable cylinder.

Written Test

d. The EPA requires that all manufacturers of recovery/recycling machines have the machines certified by Underwriters Laboratories to establish the type or types of refrigerant for which they are designed and performance levels, especially for liquid and vapor (**recovery rates**) (**limitations**).

e. The EPA also requires that businesses servicing or disposing of ACR equipment certify to EPA that they have acquired recovery or recycling equipment and that they are complying with (**applicable requirements**) (**disposal regulations**).

4. Select true statements about recovery and recycling safety. Place an "X" beside each true statement.

______a. Liquid refrigerant under pressure can cause skin damage, and all hoses contain liquid under pressure, so wear safety goggles and protective gloves when working with recovery/recycling equipment.

______b. Recover refrigerant into a non-refillable tank only as a temporary measure.

______c. Mix refrigerants only when you need to.

______d. Never fill a recovery cylinder to more than 95% full; use an automatic shut-off device if available.

______e. Always check the tare weight on a recovery cylinder and add it to the weight of the recorded refrigerant to get the net weight of the cylinder; you will need this information for local records and for shipping, if the refrigerant is going off-site for reclamation.

______f. Always disconnect a recovery/recycling machine before any servicing, and that especially includes replacing filters.

______g. If your equipment does not have some kind of automatic tank cooling, stop when you have the recovery cylinder half full.

5. Complete statements about ARI Standard 700 and its applications. Circle the material that best completes each of the following statements.

a. Reclaimed CFCs will probably be around as long as EPA regulations permit, and it is important that recycled CFCs retain a (**purity**) (**flourine**) level high enough that customers can use it with confidence.

b. The quality requirements for reclaimed refrigerants appear in ARI Standard 700-88 and 700-93, a standard which reflects input from equipment and (**compressor**) (**service equipment**) manufacturers and refrigerant producers.

Written Test

c. Better known as ARI-700, the standard specifies tests for physical properties, liquid- and vapor-phase contaminants, tests for particulates, and chemical analysis for acidity and (**water**) (**CFC**) content.

d. Reusing refrigerant not properly reclaimed can cause all kinds of service headaches and, in many cases, void equipment warranties that specify refrigerant (**quality**) (**by brand name**).

e. Quality reclaiming labs use state-of-the-art equipment including gas chromatographs, infrared spectrometers, and sophisticated moisture indicators; add to this the required chemical analysis and you can see why on-site reclaiming is (**not recommended**) (**not allowed**) for residential and commercial ACR service.

6. Complete statements about guidelines for using DOT 39 disposable refrigerant cylinders. Circle the material that best completes each of the following statements.

   a. DOT Specification CFR 39 covers design specifications and other regulations that govern the transportation and use of disposable cylinders, and disposable cylinders are usually known as (**"toss-aways"**) (**"DOT 39" cylinders**).

   b. DOT 39 cylinders are equipped with non-refillable, one-way valves so they cannot be filled again; in fact, the cylinder should be checked to make sure it is at (**zero**) (**less than 5**) psi, the valve should be disabled, and the cylinder disposed of as scrap metal.

   c. Disposable cylinders need to be stored in dry locations that are not subject to extreme (**heat**) (**condensation**), and they must be transported carefully to avoid scraping or denting painted surfaces that could lead to corrosion or weaken the cylinder.

   d. The penalty for transporting a refilled disposable cylinder can cost up to $25,000 and up to (**5 years**) (**1 year**) in prison.

7. Select true statements about guidelines for using refillable refrigerant cylinders. Place an "X" beside each true statement.

   ______a. Refillable cylinders are DOT rated by size, 4BA range from capacities of 15 to 50 pounds, and 4BW cylinders range from capacities of 100 to 1,000 pounds.

   ______b. Refillable cylinders must also be designed to withstand safe limits of saturated pressure; 4BA cylinders may range from 340 psi to 400 psi, and 4BW cylinders may range from 302 psi to 1,000 psi.

______c. Another clearly distinguishing part of refillable cylinders is the liquid/vapor valve located at the top of the cylinder, designed especially for both vapor and liquid charging without having to turn the cylinder upside down.

______d. Many refillable refrigerant cylinders have an important built-in safety device, a stop-fill device that automatically shuts a recovery machine off when liquid reaches a 95% level in a recovery cylinder.

______e. Refillable cylinders normally have important weight information included on the label or stamped into the cylinder; this information includes the water capacity, the tare weight of the empty cylinder, and the cylinder volume.

______f. When cylinders can't be shipped immediately, store them in a cool, dry area free from any heat source because heat will expand the refrigerant and could cause a dangerous explosion.

______g. Any DOT cylinder used to transport refrigerant has to be hydrostatically tested every 10 years, and there is a last test date or date of manufacture stamped on the cylinder to indicate when a new test must be made.

8. Solve problems about basic recovery devices. Circle the number in front of the statement that best solves each of the following problems.

   a. You are servicing a refrigerator with less than five pounds of refrigerant in it. As a recovery retainer you plan to use a plastic bag. A coworker laughs at you for thinking you could use a plastic bag to hold refrigerant. The coworker has a problem, what is it?

      (1) The coworker doesn't understand that plastic bags can be used for refrigerant recovery in emergency situations on any size unit.

      (2) The coworker obviously doesn't know that plastic bags with special seals are frequently used on systems that hold five pounds of refrigerant or less and in situations where the refrigerant will be placed back into the system immediately after service.

      (3) The coworker obviously doesn't know the old rule about service: do it as fast as you can with the least amount of expense.

   b. You are looking over your recovery setup on the job site to make sure you have everything you need; you have a basic recovery machine and you know it contains a metering device and its own condenser, evaporator, and compressor, but what is missing?

      (1) You need a P/T chart.

      (2) You need a scale to weigh the refrigerant you recover.

      (3) You need a DOT recovery cylinder to hold the refrigerant you recover.

Written Test

9. Solve problems about basic recovery processes. Circle the number in front of the statement that best solves each of the following problems.

   a. You are setting up a recovery machine to remove refrigerant from a system when a coworker tells you that a little hand pump could do the same thing and the expense would be far less. The problem is:

      (1) The hand pump may cost less, but it can only remove refrigerant as a liquid, which means the refrigerant will still contain some oil and can only be returned to the system it came from or to a similar system.

      (2) A recovery machine costs more, but it uses a metering device to turn the refrigerant into a vapor so the oil will separate from the refrigerant, and then condenses the vapor back into a liquid to speed the recovery process, and the recovered refrigerant has a higher purity level.

   b. You have finished a recovery procedure, but you notice that the system has slowly developed a positive pressure. The problem is:

      (1) You must have hurried the job and simply failed to recover all of the refrigerant.

      (2) After initial shutdown there is sometimes residual evaporation which will produce a positive pressure, and this indicates that a second or continued recovery can be initiated.

10. Solve problems about EPA required evacuation practices during recovery. Circle the number in front of the statement that best solves each of the following problems.

    a. A coworker helping get equipment ready for disposal says that one of the units is leaking and cannot be evacuated. You know the coworker is right, but you also know the problem is:

       (1) The unit must be registered as a leaky unit before it can be disposed of.

       (2) Leaking components should be isolated form non-leaking components so the non-leaking components can be evacuated, if possible.

    b. You have been assigned the task of opening an appliance for service, and you know it has to be evacuated, but you don't know how far the appliance has to be evacuated. To solve the problem, you should:

       (1) Evacuate the appliance as much as you can; this takes extra time, but you're playing it safe.

       (2) Look for the information in EPA Table 1; chances are the company has it prominently posted in the shop and in service vehicles.

Written Test

11. Select true statements about special considerations for disposing of small appliances. Place an "X" beside each true statement.

______a. Larger ACR systems such as retail food refrigerators are usually dismantled on site after technicians have removed the refrigerant, but small appliances such as household refrigerators and motor vehicle air conditioners pose special disposal problems.

______b. Most small appliances are disposed of by consumers, and the appliances enter the waste stream with the refrigerant charge intact.

______c. The EPA requires that the "final person in the disposal chain" be responsible for ensuring that the refrigerant has been removed, although most disposal sites still accept appliances with the refrigerant charge still in them.

______d. Most city, town, and community waste services now pick up discarded appliances only if they are tagged as having had the refrigerant removed.

______e. To solve the "small appliance discard" problem, many local ACR companies offer evacuation services free or at little cost to residents who want to discard old appliances.

______f. In other communities, evacuation is administered by the local government, and technicians should inquire of local officials what the local codes require so they can properly advise their customers who may have old appliances to discard.

______g. EPA guidelines many change as local or national situations demand, but for the most part, any technician who spots an appliance destined for the dump should not be concerned whether it is properly tagged or not.

12. Select true statements about recycling equipment and processes. Place an "X" beside each true statement.

______a. After recovery, if refrigerant quality is suspect, it should be recycled before being returned to the system, or stored, recycled, and then returned to the original system or a similar system owned by the same person.

______b. A recycling machine has the same components as a recovery machine except for the addition of an oil separator between the metering device and the evaporator.

______c. Since some oil gets into almost all refrigerant during normal operation, recycling machines feed refrigerant in the vapor state into an oil separator so oil can be separated form the refrigerant.

______d. Oil removed from a system during recycling must be saved so that it can be measured and replaced, but the same oil should never be put back into a system.

______e. Recycling differs form basic recovery in that recycling requires multiple passes through a filter and the oil separator, and recycling differs from reclaiming in that it is usually performed on-site and it does not offer the distillation and analysis required for reclaiming refrigerant.

13. Complete statements about the reclaiming process. Write in the information that best completes each of the following statements.

a. After recovery, a suspect refrigerant should be reclaimed at an approved facility equipped to perform the complicated distillation and analysis required to assure the refrigerant meets ARI Standard ________________.

b. Once reclaimed, refrigerant may be shipped back to the original owner, kept in a refrigerant ________________, or resold to a ________________ buyer.

c. Some highly contaminated refrigerant cannot be reclaimed, but it should be sent to a reclaiming center where it can be ________________.

d. Service technicians handling refrigerant headed for a reclaiming facility need to carefully complete all required ________________ to assure that the refrigerant is properly tracked for accounting and tax purposes.

14. Select true statements about recovery system characteristics and their applications. Place an "X" beside each true statement.

______a. Make sure the recovery cylinder is empty and is free of the damaging non-condensables, air, and water.

______b. Make sure all hoses that will be used in the recovery have been safely vented and are clean.

______c. Be sure that the recovery cylinder has a liquid level switch that will automatically shut off the recovery process when the cylinder is 80% full, or determine how much the cylinder should weigh when it is 80% full and have a scale on which the cylinder can be weighed.

______d. Make sure your recovery meets EPA recovery levels; if the low pressure cutout on the recovery equipment stops the recovery, wait awhile to see if refrigerant left in the system will raise the pressure and start the recovery process again.

______e. Do not recover past specified limits; if there are non-condensables in the system, they can be drawn into the recovery cylinder.

Written Test

______f. Pay attention to ambient temperature and use cooling devices if the situation demands because cooler temperatures speed recovery time.

______g. Never mix refrigerants in a recovery cylinder!

______h. Keep records of every recovery process so that refrigerant can be tracked for accounting purposes, and keep track of problems that may add to recovery time or safe procedures that speed recovery time; a good technician can truly help determine company operating procedures.

15. Complete statements about improperly mixed refrigerants and how to avoid them. Write in the information that best completes each of the following statements.

    a. The best way to avoid improper mixing is to use a separate recovery machine for each type of refrigerant or make sure the recovery machine you use is ________________ ________________.

    b. After refrigerant is removed from a recovery machine, there are two more important steps required before the machine can be used with another refrigerant, and those steps are:

        (1) Remove and replace the ________________ in the recovery machine.

        (2) Remove and replace any ________________ used for recovery.

16. Select true statements about recovery system characteristics and their applications. Place an "X" beside each true statement.

______a. The primary rule for using any recovery system is to read the operating manual before you use the equipment; some of the information may not be absolutely vital to operation, but be sure to carefully read the start-up procedures.

______b. Some systems are factory charged with nitrogen and the nitrogen has to be vented before the equipment can be set up or used.

______c. Some systems require charging before recovery starts, and they must always be charged with nitrogen.

______d. Many systems have built-in or in-line filters designed to protect the compressor on the recovery equipment; these filters perform the same job that recycling filter-driers perform.

Written Test

_______e. Use only DOT-approved refillable cylinders to recover refrigerant; transporting a refilled disposable cylinder can result in a hefty fine and imprisonment.

_______f. When at all possible, recover refrigerant into a cylinder with a float switch to prevent filling the cylinder to more than 80% capacity; if the recovery cylinder does not have a float switch, scales must be used to determine when the cylinder is 80% full.

_______g. Oil in a recovery machine should be changed after each third or fourth use.

_______h. Some recovery machines have a sight glass so the refrigerant quality can be monitored after it passes through the oil trap and filters; check the operator's manual for conditions to look for to indicate moisture problems.

_______i. Recover system refrigerant as a vapor when possible because recovering liquid refrigerant takes significantly longer.

17. Select true statements about recovery/recycling system characteristics and applications. Place an "X" beside each true statement.

_______a. Machines that both recover and recycle have become popular configurations in AC service because most of them make the recovery/recycling process a highly automated procedure.

_______b. As with all equipment, the first rule for using R/R/ equipment is to read the operating manual, and read everything in the manual because procedures with one part of a system may have significant affects on other parts of the system.

_______c. Some new units are factory charged with refrigerant which must be vented before using the equipment.

_______d. Some new units also require that filter driers be installed prior to a first-time use; replace filters as the equipment manufacturer requires at critical points in the recovery/recycling process.

_______e. Hook the recovery cylinder up to a vacuum pump and pull it down to a vacuum to make sure it is free of unwanted air and moisture.

_______f. Make sure the recovery cylinder is a DOT-approved refillable cylinder.

_______g. Some types of recovery/recycling units have built-in scales; center the recovery cylinder on the scales and secure it so it won't tip over.

Written Test

18. Complete statements about how to make an in-line filter. Write in the information needed to complete each of the following statements.

    a. A technician may sometime have to make an in-line filter if a recovery unit does not have a filter because recovery should never be attempted without a ____________________.

    b. Using quick-connect fittings when you make an in-line filter will make it easy to reverse the filter after recovery so refrigerant can be ____________ ____________ ____________ ____________ ____________.

*Permission to duplicate this test is granted.

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Job Sheet 1—Use a Hand-Operated Pump to Recover Refrigerant From a Small AC or Refrigeration System Rating _____

Comments: ______________________

____

Job Sheet 2—Use a Recovery Machine to Recover Refrigerant From an AC or Refrigeration System Rating _____

Comments: ______________________

____

Job Sheet 3—Use a Recovery/Recycling Machine to Recover/Recycle Refrigerant From an AC or Refrigeration system Rating _____

Comments: ______________________

____

Other ______________________

____

Written Tests: Pretest _____ Posttest _____

Total _____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

697

Permission to duplicate this form is granted.

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Information Sheet

1. **Terms and definitions**

    a. **Improperly mixed refrigerant** — The accidental or purposeful mixing of one refrigerant type with a different refrigerant type within a system, recovery device, or recovery cylinder

    b. **Reclaiming** — To reprocess refrigerant to new product specifications by means which may include distillation; chemical analysis of the product is required to determine that appropriate product specifications are met; the term usually implies the use of processes or procedures available only at a reprocessing or manufacturing facility

    c. **Recovery**— To remove refrigerant in any condition from a system and store it in a container without necessarily testing it or processing it in any way

    d. **Recycling**— To reduce contaminants in used refrigerant by oil separation and single or multiple passes through devices which remove moisture, acidity, and particulate matter, such as replaceable core filter driers; the term usually applies to procedures implemented at the field job site or at a local service shop

    e. **Reuse** — To return recovered, recycled, or reclaimed refrigerant to an operational system

    f. **Small appliances** — Products that are fully manufactured in a factory where they are charged and hermetically sealed with five pounds or less of refrigerant

    g. **Virgin refrigerant** — Brand new refrigerant that has never been used, recovered, recycled, or reclaimed

2. **General recovery, recycling, and reclaiming requirements**

    a. In the days before EPA "no venting" regulations, servicing an ACR system usually meant opening a service valve and venting refrigerant into the atmosphere, but this process is now illegal.

    b. Former recovery processes sometimes called for saving system refrigerant, but under new guidelines "saving refrigerant" is not optional, it must be done even if the amount of refrigerant removed is minimal.

    c. Recovery must also include evacuation to required EPA levels, and this depends on the type of system, type of refrigerant, and what shape the system is in regarding leaks or condition of components.

Information Sheet

d. The most frequently used process is to recover refrigerant, service the system, and reuse the original refrigerant after service.

e. In cases where recovered refrigerant may evidence contamination, the recovered refrigerant can be recycled on-site for immediate reuse or recycled at a local shop and reused at a later date in the same owner's equipment.

f. In cases where recovered refrigerant is badly contaminated, the refrigerant can be shipped to an off-site reclaiming center for processing and cleaning to meet ARI 700 quality standards.

g. In cases where recovered refrigerant is so badly contaminated that it cannot be cleaned, it should be shipped to an off-site reclaiming center to be destroyed.

Note: There is no such thing as "throwing away" badly contaminated refrigerant. It must be destroyed by an authorized agency. Persons caught disposing of contaminated refrigerant improperly are subject to heavy fines.

3. EPA recovery methods and certification

a. The EPA defines two recovery methods that affect how much of a system charge must be evacuated from a small appliance; those methods are self-contained and system-dependent.

b. Self-contained recovery is made without the aid of the compressor in a system, usually entails the use of a recovery/recycling machine, and is the most common method of recovering refrigerant.

c. System-dependent recovery is made with the help of a system compressor and refrigerant may be collected in the liquid receiver of the system itself, or in a refillable cylinder.

Note: The EPA once defined self-contained recovery as "active recovery" and system-dependent recovery as "passive recovery", but the definitions above reflect the new EPA terminology on the subject.

d. The EPA requires that all manufacturers of recovery/recycling machines have the machines certified by Underwriters Laboratories to establish the type or types of refrigerant for which they are designed and performance levels, especially for liquid and vapor recovery rates.

e. The EPA also requires that businesses servicing or disposing of ACR equipment certify to EPA that they have acquired recovery or recycling equipment and that they are complying with applicable requirements.

Information Sheet

4. Recovery and recycling safety

a. Liquid refrigerant under pressure can cause skin damage, and all hoses contain liquid under pressure, so wear safety goggles and protective gloves when working with recovery/recycling equipment.

b. Do not recover refrigerant into a non-refillable tank; this is not only against the law, it is extremely dangerous; use only a DOT-approved refillable cylinder.

c. Do not mix refrigerants; make sure your recovery cylinder is designated for use with the refrigerant you are recovering.

d. Never fill a recovery cylinder to more than 80% full; use an automatic shut-off device if available.

e. Always check the tare weight on a recovery cylinder and add it to the weight of the recorded refrigerant to get the net weight of the cylinder; you will need this information for local records and for shipping, if the refrigerant is going off-site for reclamation.

f. Always disconnect a recovery/recycling machine before any servicing, and that especially includes replacing filters.

g. If your equipment does not have some kind of automatic tank cooling, cool the recovery cylinder when liquid recovery ends and the system starts slowing down as it begins to recover vapor; cooling jackets are made for this purpose, and sometimes a pan of ice cubes will serve the purpose.

5. ARI Standard 700 and its applications

a. Reclaimed CFCs will probably be around as long as EPA regulations permit, and it is important that recycled CFCs retain a purity level high enough that customers can use it with confidence.

b. The quality requirements for reclaimed refrigerants appear in ARI Standard 700-88 and 700-93, a standard which reflects input from equipment and compressor manufacturers and refrigerant producers.

c. Better known as ARI-700, the standard specifies tests for physical properties, liquid- and vapor-phase contaminants, tests for particulates, and chemical analysis for acidity and water content.

Information Sheet

ARI STANDARD 700

Physical Properties of Fluorocarbon Refrigerants and Maximum Contaminant Levels

	REFRIGERANTS								
	R11	R12	R13	R22	R113	R114	R500	R502	R503
PHYSICAL PROPERTIES Boiling point F @ 29.9 in. Hg	74.9 (23.8)	−21.6 (−29.8)	−114.6 (−81.4)	−41.4 (−40.8)	117.6 (47.6)	38.8 (3.8)	−28.3 (−33.5)	−49.8 (−45.4)	−127.6 (−88.7)
Boiling range °F for 5% to 85% by volume distilled	0.5	0.5	0.9	0.5	0.5	0.5	0.9	0.9	0.9
VAPOR PHASE CONTAMINANTS Air and other non-condensables (in filled container) Max. % by volume	—	1.5	1.5	1.5	—	1.5	1.5	1.5	1.5
LIQUID PHASE CONTAMINANTS Water—ppm by weight	10	10	10	10	10	10	10	10	10
Chloride ion—no turbidity to pass by test	pass	pass	pass	pass	pass	pass	pass	pass	pass
Acidity—Max. ppm by weight	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
High boiling residues—Max. % by volume	0.01	0.01	0.05	0.01	0.03	0.01	0.05	0.01	0.01
Particulate/solids—visually clean to pass	pass	pass	pass	pass	pass	pass	pass	pass	pass
Other refrigerants—Max. % by weight	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Courtesy National Refrigeration Products

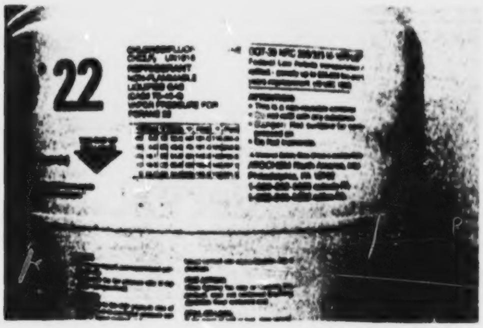
d. Reused refrigerant not properly reclaimed can cause all kinds of service headaches and, in many cases, void equipment warranties that specify refrigerant quality.

e. Quality reclaiming labs use state-of-the-art equipment including gas chromatographs, infrared spectrometers, and sophisticated moisture indicators; add to this the required chemical analysis and you can see why on-site reclaiming is not recommended for residential and commercial ACR service.

6. **Guidelines for using DOT 39 disposable refrigerant cylinders**

a. DOT Specification CFR 39 covers design specifications and other regulations that govern the transportation and use of disposable cylinders, and disposable cylinders are usually known as "DOT 39" cylinders.

Information Sheet



b. DOT 39 cylinders are equipped with non-refillable, one-way valves so they cannot be filled again; in fact, the cylinder should be checked to make sure it is at zero psi, the valve should be disabled, and the cylinder disposed of as scrap metal.

c. Disposable cylinders need to be stored in dry locations that are not subject to extreme heat, and they must be transported carefully to avoid scraping or denting painted surfaces that could lead to corrosion or weaken the cylinder.

d. The penalty for transporting a refilled disposable cylinder can cost up to $25,000 and up to 5 years in prison.

7. **Guidelines for using refillable refrigerant cylinders**

a. Refillable cylinders are DOT rated by size, 4BA range from capacities of 15 to 50 pounds, and 4BW cylinders range from capacities of 100 to 1,000 pounds.

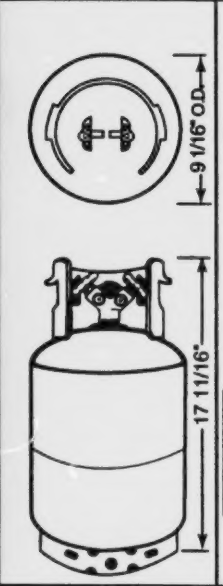
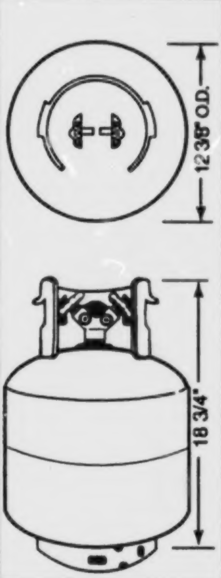
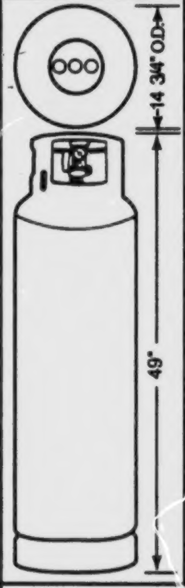
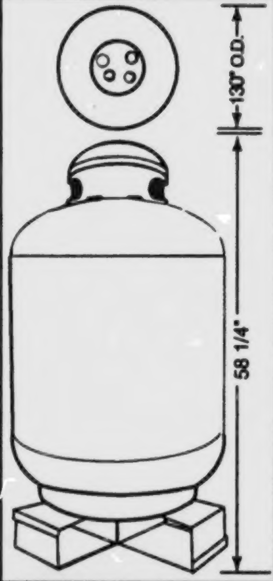
b. Refillable cylinders must also be designed to withstand safe limits of saturated pressure; 4BA cylinders may range from 340 psi to 400 psi, and 4BW cylinders may range from 302 psi to 1,000 psi.

c. Another clearly distinguishing part of refillable cylinders is the liquid/vapor valve located at the top of the cylinder, designed especially for both vapor and liquid charging without having to turn the cylinder upside down.

d. Many refillable refrigerant cylinders have an important built-in safety device, a stop-fill device that automatically shuts a recovery machine off when liquid reaches an 80% level in a recovery cylinder.

e. Refillable cylinders normally have important weight information included on the label or stamped into the cylinder; this information includes the water capacity, the tare weight of the empty cylinder, and the cylinder volume.

Information Sheet

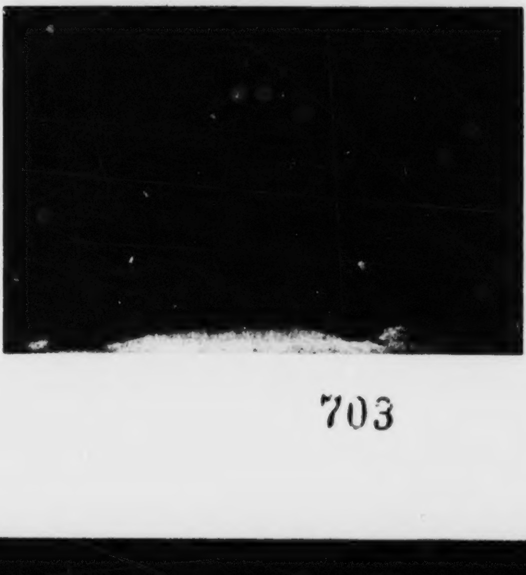
	26.2 LB. WATER CAPACITY*	47.7 LB. WATER CAPACITY*	240 LB. WATER CAPACITY*	1000 LB. WATER CAPACITY*
				
Tare Weight	13.7 lbs.	24.0 lbs.	86 lbs.	356 lbs. w/lift truck rails (4way pallet entry) standard
Cyl. volume	726 cu. in.	1323 cu. in.	6596 cu. in.	27686 cu.in. Float gauge is standard.
Footring o/s dia.	7-13/16 in. DOT-4BA-350	7-13/16 in. DOT-4BA-350	14 in. DOT-4BW-260	23 in. DOT-4BW-260

Courtesy Worthington Cylinder Corporation

f. When cylinders can't be shipped immediately, store them in a cool, dry area free from any heat source because heat will expand the refrigerant and could cause a dangerous explosion.

g. Any DOT cylinder used to transport refrigerant has to be hydrostatically tested every 5 years, and there is a last test date or date of manufacture stamped on the cylinder to indicate when a new test must be made.

Note: The fine for using an untested cylinder can run up to $25,000, and the cylinder's new owner is responsible for having the testing done.



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Information Sheet

8. Basic recovery devices

a. The most basic recovery device is an electric or hand-operated pump that takes the refrigerant directly form the system to a recovery container.

b. The most basic recovery container is a plastic bag designed with a special seal to assure no refrigerant is released to the atmosphere during transfer from or back to the system.

Note: Plastic bags are generally reserved for use with small appliances with charges of less than five pounds in situations where the refrigerant will be placed back into the system immediately after service.

c. A basic recovery machine consists of a metering device, an evaporator, a compressor, a condenser, and an approved DOT cylinder to hold the refrigerant.

d. Some recovery systems are dolly-mounted for mobility or lightweight enough to be easily hand-carried to an on-site AC system.

Note: There are also truck- or van-mounted recovery systems that work with extended hose lengths to complete recovery.

9. Basic recovery processes

a. In a really basic recovery process, refrigerant is removed from a system, placed in storage while system repair or maintenance is completed, and then returned to the system.

b. With a recovery machine, refrigerant is first taken from the system in a liquid state, drawn through a metering device to turn it into a vapor, then channeled through the compressor where it is compressed back into a high pressure state so that it can be condensed back into a liquid at the condenser and transferred to an approved storage cylinder.

c. Turning the refrigerant into a vapor seems like an extra step, but liquid refrigerant must be turned into a vapor so the oil will separate from the refrigerant, and then it is turned back into a liquid to speed the recovery process.

d. A recovery process may include filtering between the system and the recovery cylinder as the refrigerant is removed or filtering between the cylinder and the system as the refrigerant is returned to the system.

e. Most recovery systems have automatic low pressure controls to indicate termination of the recovery process.

f. Recovery is always an on-site process, but recycling may be completed off-site, and reclaiming is almost always completed off-site.

g. After initial shutdown, residual evaporation of refrigerant in the system may develop a positive pressure or the evacuation level may rise so that a second or continued recovery can be initiated to comply with required EPA recovery levels.

10. EPA required evacuation practices during recovery

a. Except for MVACs, all persons opening appliances for maintenance, service, or repair must evacuate the refrigerant in either the entire unit or the part to be serviced into a system receiver or a certified recovery or recycling machine.

b. All persons disposing of all appliances, except small appliances, MVACs, and MVAC-like appliances must evacuate the refrigerant in the entire unit into a certified recovery or recycling machine.

c. Except for MVACs or MVAC-like appliances, persons opening appliances for maintenance, service, or repair must, with some exceptions, evacuate to EPA prescribed levels listed in EPA's Table 1 before opening the appliance.

Type of air-conditioning or refrigeration equipment	Inches of vacuum (relative to standard atmospheric pressure of 29.9 inches Hg)[1]	
	Using recovery or recycling equipment manufactured before November 15, 1993	Using recovery or recycling equipment manufactured on or after November 15, 1993
HCFC-22 equipment, or isolated component of such equipment, normally containing less than 200 pounds of refrigerant	0	0
HCFC-22 equipment, or isolated component of such equipment, normally containing 200 pounds or more of refrigerant	4	10
Other high-pressure equipment, or isolated component of such equipment, normally containing less than 200 pounds of refrigerant	4	10
Other high-pressure equipment, or isolated component of such equipment, normally containing 200 pounds or more of refrigerant	4	15
Very high-pressure equipment	0	0
Low-pressure equipment	25	29

d. ACR service companies should keep EPA Table 1 prominently posted in company service areas and in service vehicles.

e. Exceptions to Table 1 requirements are situations where the required levels cannot be obtained because of system leaks or conditions that would contaminate the refrigerant.

Information Sheet

f. In the event a system leak does not permit evacuation to a prescribed level, isolate the leaking from non-leaking components, if possible, and evacuate the non-leaking components to required levels.

g. All persons recovering refrigerant from small appliances for the purpose of disposing of those appliances must evacuate 90% of the refrigerant if the appliance compressor is operating, 80% of the refrigerant if the compressor is not operating, or to a vacuum of 4" hg if at least 80% evacuation cannot be obtained.

11. Special considerations for disposing of small appliances

a. Larger ACR systems such as retail food refrigerators are usually dismantled on site after technicians have removed the refrigerant, but small appliances such as household refrigerators and motor vehicle air conditioners pose special disposal problems.

b. Most small appliances are disposed of by consumers, and the appliances enter the waste stream with the refrigerant charge intact.

c. The EPA requires that the "final person in the disposal chain" be responsible for ensuring that the refrigerant has been removed, and this poses problems because disposal sites that used to accept such appliances now refuse them.

d. Most city, town, and community waste services now pick up discarded appliances only if they are tagged as having had the refrigerant removed.

e. To solve the "small appliance discard" problem, many local ACR companies offer evacuation services free or at little cost to residents who want to discard old appliances.

Note: The recovered refrigerant usually makes it economically worthwhile for the local companies, and it provides companies with excellent public relations.

f. In other communities, evacuation is administered by the local government, and technicians should inquire of local officials what the local codes require so they can properly advise their customers who may have old appliances to discard.

g. EPA guidelines may change as local or national situations demand, but for the most part, any technician who spots an appliance destined for the dump should report it to a responsible authority if the appliance is not tagged as having been evacuated.

Note: Reporting a violation doesn't make a person a "snitch"; in fact, the EPA does not require a bunch of paperwork to prove that refrigerant management is taking place, rather, the EPA notes that the regulations must be "self effectuating" meaning that people in the business must make them work as a matter of "good faith."

Information Sheet

12. Recycling equipment and processes

a. After recovery, if refrigerant quality is suspect, it should be recycled before being returned to the system, or stored, recycled, and then returned to the original system or a similar system owned by the same person.

Note: EPA regulations about the sale of refrigerant recycled on-site may change as on-site quality standards develop. Check with your instructor about current conditions.

b. A recycling machine has the same components as a recovery machine except for the addition of an oil separator between the metering device and the evaporator, and a replaceable filter drier.

c. Since some oil gets into almost all refrigerant during normal operation, recycling machines feed refrigerant in the vapor state into an oil separator so oil can be separated from the refrigerant.

d. Oil removed from a system during recycling must be saved so that it can be put back into a system, or measured and replaced if it is contaminated.

e. Recycling differs form basic recovery in that recycling requires multiple passes through a filter and usually an oil separator, and recycling differs from reclaiming in that it is usually performed on-site and it does not offer the distillation and analysis required for reclaiming refrigerant.

13. The reclaiming process

a. After recovery, a suspect refrigerant should be reclaimed at an approved facility equipped to perform the complicated distillation and analysis required to assure the refrigerant meets ARI Standard 700.

b. Once reclaimed, refrigerant may be shipped back to the original owner, kept in a refrigerant bank, or resold to a certified buyer.

c. Some highly contaminated refrigerant cannot be reclaimed, but it should be sent to a reclaiming center where it can be destroyed.

d. Service technicians handling refrigerant headed for a reclaiming facility need to carefully complete all required paperwork to assure that the refrigerant is properly tracked for accounting and tax purposes.

Note: Some refrigerant management companies store both virgin and reclaimed refrigerant for their clients, and even "lease" CFC-12 for retrofit flushing; most important, as of January 1 each year CFCs in quantities over 400 pounds are subject to a special tax, so types and quantities of refrigerant must be properly accounted for.

Information Sheet

14. Guidelines for effective recovery

a. Make sure the recovery cylinder is empty and is free of the damaging non-condensables, air, and water.

b. Make sure all hoses that will be used in the recovery have been safely vented and are clean.

c. Be sure that the recovery cylinder has a liquid level switch that will automatically shut off the recovery process when the cylinder is 80% full, or determine how much the cylinder should weigh when it is 80% full and have a scale on which the cylinder can be weighed.

d. Make sure your recovery meets EPA recovery levels; if the low pressure cutout on the recovery equipment stops the recovery, wait awhile to see if refrigerant left in the system will raise the pressure and start the recovery process again.

e. Do not recover past specified limits; if there are non-condensables in the system, they can be drawn into the recovery cylinder.

f. Pay attention to ambient temperature and use cooling devices if the situation demands because cooler temperatures speed recovery time.

g. Never mix refrigerants in a recovery cylinder!

h. Keep records of every recovery process so that refrigerant can be tracked for accounting purposes, and keep track of problems that may add to recovery time or safe procedures that speed recovery time; a good technician can truly help determine company operating procedures.

15. Improperly mixed refrigerants and how to avoid them

a. Improperly mixed refrigerants can create extreme system problems and sometimes cause permanent system damage, so improperly mixed refrigerants should never be placed into a system.

b. Improperly mixed refrigerants should be accounted for and shipped to a reclaiming center where they can sometimes be distilled and reused, but are frequently destroyed.

c. Unless you're working with a recovery machine that operates with "oil less technology", the only way to avoid improper mixing in recovery are to use a designated machine for each type of refrigerant or make sure the recovery machine is totally clean.

Note: The OZsaver™ from Thermaflo handles changing from one refrigerant to another automatically, remembers which refrigerant the machine used last and will not permit improper mixing, and its hoses self-evacuate when they are in their "pockets."

Information Sheet

d. Cleaning a recovery machine means getting all the refrigerant out, and this often entails using another recovery machine, unless the equipment has a "pumpout cycle" which is specifically designed to clear the recovery machine of all refrigerant and pump it out to a recovery cylinder.

e. After refrigerant is removed from the recovery machine, there are two more important steps required before the recovery machine can be used with a different refrigerant:

(1) Remove and replace the oil in the recovery machine.

Note: Remember, some refrigerant will mix with the oil.

(2) Remove and replace any filters used for recovery.

f. Another safeguard against improper mixing is to be sure that recovery cylinders are carefully marked with the type of refrigerant they contain, and that a cylinder marked with one type of refrigerant never be used for another type of refrigerant until it has been totally evacuated and relabeled.

16. Recovery system characteristics and applications

a. The primary rule for using any recovery system is to read the operating manual before you use the equipment, and don't just read the part about startup or the part about recovery—read it all!

Note: An operator's manual may be called a "guide" or some other name, but it contains essential information about activities that may not seem to be a part of the recovery process, but may still affect the recovery process.

b. Some systems are factory charged with nitrogen and the nitrogen has to be vented before the equipment can be set up or used.

c. Some systems require charging before recovery starts, and they must always be charged with the type of refrigerant that will be recovered.

d. Many systems have built-in or in-line filters designed to protect the compressor on the recovery equipment; these filters perform many of the functions that recycling filter-driers perform and recovery with this type of equipment should never be misconstrued as recycling.

e. Use only DOT-approved refillable cylinders to recover refrigerant; transporting a refillable disposable cylinder can result in a hefty fine and imprisonment.

f. When at all possible, recover refrigerant into a cylinder with a float switch to prevent filling the cylinder to more than 80% capacity; if the recovery cylinder does not have a float switch, scales must be used to determine when the cylinder is 80% full.

Information Sheet

g. Oil in a recovery machine should be changed after each use, and the oil should be disposed of safely according to state/local disposal laws, and oil removed from refrigerant must also be disposed or properly.

h. Some recovery machines have a sight glass so the refrigerant quality can be monitored after it passes through the oil trap and filters; check the operator's manual for conditions to look for to indicate moisture problems.

i. Recover system refrigerant as a liquid when possible because recovering refrigerant vapor takes significantly longer.

17. Recovery/recycling system characteristics and applications

a. Machines that both recover and recycle have become popular configurations in AC service because most of them make the recovery/recycling process a highly automated procedure.

b. As with all equipment, the first rule for using R/R equipment is to read the operating manual, and read everything in the manual because procedures with one part of a system may have significant affects on other parts of the system.

c. Some new units are factory charged with nitrogen which must be vented before using the equipment.

d. Some new units also require that filter driers be installed prior to a first-time use; replace filters as the equipment manufacturer requires at critical points in the recovery/recycling process.

e. Hook the recovery cylinder up to a vacuum pump and pull it down to a vacuum to make sure it is free of unwanted air and moisture.

f. Make sure the recovery cylinder is a DOT-approved refillable cylinder.

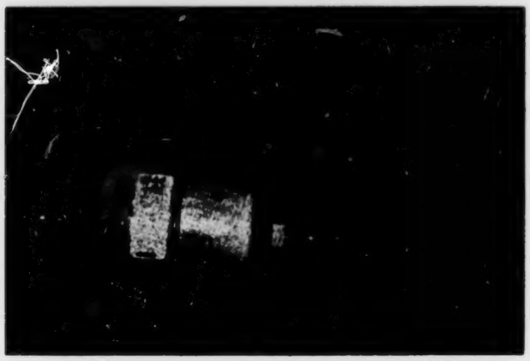
g. Some types of recovery/recycling units have built-in scales; center the recovery cylinder on the scales and secure it so it won't tip over.

18. How to make an in-line filter

a. In cases where a recovery unit may not have a filter in-line or on the unit, it may be necessary to build an in-line filter because recovery should not be attempted without one.

Information Sheet

b. Attach a hose to each end of a replaceable filter so that one connection fits the system and the other connection fits the recovery machine.



c. Use quick connect fittings so that the hose can be quickly removed after recovery, and the filter can be reversed so refrigerant can be fed back into the system.

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Student Supplement 1—Vapor and Vacuum Levels

The following scenario from National Refrigeration Products graphically presents results obtained by using an NRP R11 liquid and vapor recovery unit. The information is copyrighted© by **National Refrigeration Products** and is reprinted with permission.

To illustrate the need to recover both R11 liquid and vapor, let's take the example of a 350 ton chiller which has a charge of about 600 lbs. of R11. The chiller, which is about 15 ft. long, has a combined evaporator/condenser internal volume of about 300 cubic feet.

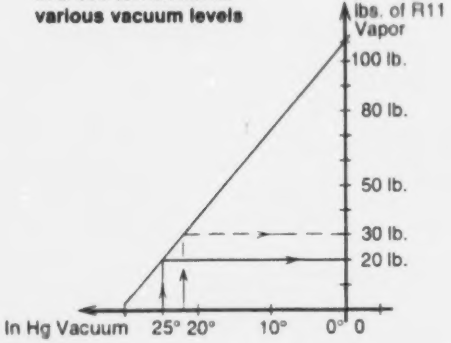
From standard refrigerant tables we find that at 0 psig R11 vapors weight. 364 lbs./cu.ft. After removing all the R11 liquid, the 350 ton chiller which has a volume of 300 cu. ft. will hold about 109 lbs. of vapor at 0 psig. About 500 lbs. of R11 should have been removed in liquid form.

If we recover to a vacuum of 22" Hg, about 30 lbs. of vapor will remain which is 5% of the total charge. At a vacuum level of 26" Hg, only 18 lbs. of vapor would be left which is 3% of the total charge.

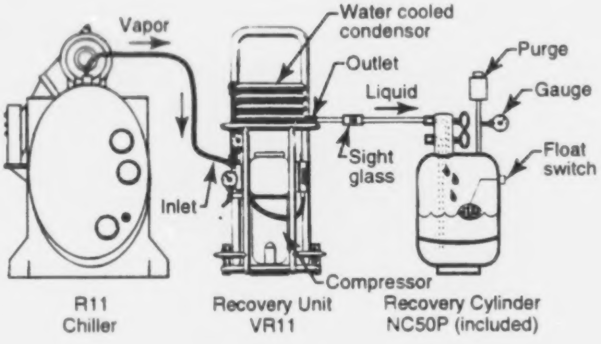
The final vacuum level obtained in the chiller will depend on the amount of time spent evacuating and on the amount of air leakage into the chiller. The vapor recovery rate and the time required for evacuation will be affected by the recovery line size and the chiller connection size. If you connect a ¾" recovery line to a 1" fitting at the chiller, the evacuation rate will be faster than if you connect to a ¼" fitting.

When recovering R11 from a chiller, it should be expected that less refrigerant than the designed charge shown on the name plate will be recovered. R11 chillers lose 10% or more of their charge every year. The refrigerant losses are due to the purge unit operation, valve leaks, or other leaks. All these losses greatly reduce the actual amount of R11 in the chiller.

Pounds of vapor left in a 350 ton chiller at various vacuum levels



Vapor Recovery



Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Job Sheet 1—Use a Hand-Operated Pump to Recover Refrigerant From a Small AC or Refrigeration System

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Hand-operated pump checked and properly set up	______
Recovery cylinder checked and properly set up	______
"De minimus" venting regulation properly applied	______
Service form properly completed	______

A. Tools and materials

Air conditioning or refrigeration system with 3 lbs. or less of refrigerant charge
Recovery pump and operator's guide as selected by instructor
Recovery cylinder with automatic shut-off switch
Recovery hoses or hoses from a manifold gauge set
Open end wrench and refrigerator service wrench
Safety glasses, service form and pen or pencil

B. Procedure

> Note: This procedure is for Indianapolis Refrigeration Company's Spooter II or Spooter 134 manually-operated refrigerant pump and is reprinted with permission. Your instructor may modify the procedure to include available local equipment. The brand name references typical application; no endorsement is intended.

☐ 1. Make appropriate entries on the service form that accompanies this job sheet, and be sure to complete the form so it can be part of your instructor's evaluation.

☐ 2. Put on safety glasses.

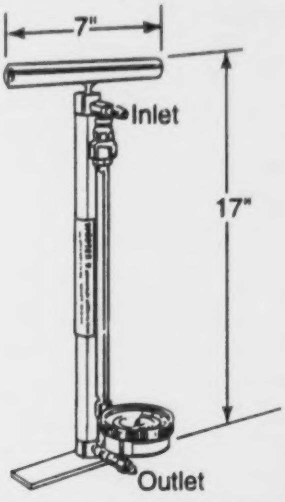
☐ 3. Make sure the refrigeration system is off.

Job Sheet 1

☐ 4. Prepare a refillable recovery cylinder to receive refrigerant from the system; use a cylinder with an automatic 80% full shut-off device, or weigh the cylinder on a set of properly calibrated scales so you will know when the cylinder is 80% full.

☐ 5. Connect one end of your first evacuation hose to the top port, inlet port, of the pump, and connect the other end of the hose to the service port on the liquid line of the system.

☐ 6. Connect one end of your second evacuation hose to the bottom port, outlet port, of the pump, and connect the other end of the hose to the vapor inlet valve on the recovery cylinder.



Courtesy Indianapolis Refrigeration Company

☐ 7. Before you open the vapor inlet on the recovery cylinder, crack the hose at that inlet to purge air out of both hoses and the pump.

☐ 8. Pump the handle up and down as many times as required to remove refrigerant from the system to the recovery cylinder.

☐ 9. Monitor the pump until the system is evacuated to the level specified for the type of refrigerant being recovered, and then stop pumping.

Note: If you started with a clean recovery cylinder, there is no need to monitor the weight of the refrigerant being removed, but if the system you are working with had more than a 3 pound charge, or the cylinder contained a previous amount of the same type of refrigerant you are evacuating, you should monitor the scales to make sure you do not exceed the 80% fill limit. And if you have trouble finding the specified evacuation level, ask your instructor for help. This is an EPA requirement that you must become used to.

Job Sheet 1

☐ 10. Look at your watch or an available clock and allow the system to remain hooked up and idle for 5 minutes.

☐ 11. If pressure in the system rises above the specified level, start pumping again, and continue pumping until the system is evacuated back to the proper level.

☐ 12. Time the system again for 5 minutes, and repeat pumping as required until the system stays at the proper evacuation level for at least 5 minutes.

☐ 13. Close the outlet hose at the pump and remove it, but leave the other end attached to the recovery cylinder until another evacuation is needed.

Note: This effectively limits vented refrigerant to the amount between the pump and the hose shut off, and complies with "de minimus" venting regulations.

☐ 14. Check the weight of the refrigerant removed from the system and enter that amount here ____________________ and on your service form.

☐ 15. Disconnect the upper hose from the pump and the system and replace the caps on the system service port and the inlet of the pump.

☐ 16. Lubricate the hand pump to specifications outlined int he operator's manual.

☐ 17. Have your instructor check your evacuation procedure and your service form.

☐ 18. Secure equipment and return tools and materials to proper storage.

Evaluator's comments: ____

____

____

Job Sheet 1

Service Work Order

Customer's Name ____________________

Customer's Address ____________________

Brief description of problem ____________________

____

____

Time and date service or repair started ____________________

Time and date service or repair ended ____________________

Materials or equipment used to complete service or repair (continue list on back of form if needed) ____________________

____

____

____

Was refrigerant removed from system during service? ☐ Yes ☐ No
If refrigerant was removed, what was the disposition of the refrigerant removed?
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight ____________________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? ____________________
What amount of refrigerant was added? ____________________
Were appropriate service tags left on system for future service reference? ☐ Yes ☐ No
Note: If you added refrigerant, the service tag should indicate both date and amount.

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ____________________ Date __________

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Job Sheet 2—Use a Recovery Machine to Recover Refrigerant From an AC or Refrigeration System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Recovery machine checked and properly set up	______
Recovery cylinder checked and properly set up	______
"De minimus" venting regulation properly applied	______
Service form properly completed	______

A. Tools and materials

Air conditioning or refrigeration system as selected by instructor
Recovery machine and operator's guide as selected by instructor
Recovery cylinder with automatic shut-off switch
Manifold gauge set
Oil gauge set
Open end wrench and refrigerator service wrench
Safety glasses, service form and pen or pencil
Temperature/pressure chart and thermometer

B. Procedure

> Note: This procedure is for Thermal Engineering Company's Model 7800 Extractor Refrigerant Recovery Center and is reprinted with permission. Your instructor may change the procedure to facilitate available local equipment. The brand name references typical application; no endorsement is intended.

☐ 1. Make appropriate entries on the service form that accompanies this job sheet, and be sure to complete the form so it can be part of your instructor's evaluation.

☐ 2. Put on safety glasses.

Job Sheet 2

☐ 3. Make sure the refrigeration system is off.

☐ 4. Check to make sure that the recovery unit INLET and OUTLET valves are closed.

☐ 5. Close both manifold valves.

☐ 6. Connect the high side manifold gauge hose to the access fitting on the system liquid line to remove liquid.

Note: If you planned to remove vapor you would connect the manifold gauge hose to the discharge service valve.

☐ 7. Connect the low side hose of the manifold gauge set to the suction line service port of the system.

☐ 8. Open system valves, if necessary.

☐ 9. Purge the air from the hoses.

☐ 10. Connect the manifold center hose to the INLET fitting on the recovery unit.

☐ 11. Connect the OUTLET fitting to the vapor valve of the refrigerant recovery tank.

☐ 12. Make sure the recovery tank is upright and plug the float switch cable into the recovery cylinder and plug the other cable end into the unit.

☐ 13. Connect the recovery unit to power and turn the POWER switch ON.

☐ 14. Connect the ISOLATION valve to the EVACUATION fitting, and attach a vacuum pump to the valve.

☐ 15. Turn on the vacuum pump and open the ISOLATION valve to evacuate the hoses to the manifold and recovery cylinder.

☐ 16. Open the vapor valve to evacuate the recovery cylinder.

Note: The vapor valve should remain closed if the cylinder contains refrigerant or has been previously evacuated.

☐ 17. Close the isolation valve and turn off the vacuum pump.

Note: If the storage tank has been evacuated and is empty, open the manifold valves to allow refrigerant from the system to pressurize the recovery cylinder, and after pressures equalize, close the manifold and recovery cylinder valves.

Job Sheet 2

☐ 18. Open the INLET and OUTLET valves on the recovery unit.

☐ 19. Hold the EQUALIZE switch until the pressures in the recovery unit equalize, and then release the switch.

☐ 20. Hold the START switch in the START position until the compressor starts, and then release it.

☐ 21. Recover liquid with the following procedure:

Set the MODE switch to RECOVERY. Open the recovery cylinder vapor valve and the manifold gauge high side valve. When the recovery unit's low side gauge drops steadily, open the manifold low side valve. Once the recovery unit's low side gauge drops below 30 psi, set the MODE switch to BYPASS.

Caution: Recovering liquid with the MODE switch in the BYPASS can slug the compressor with liquid refrigerant and damage the unit, so watch the operation carefully.

☐ 22. Recover vapor with the following procedure:

Set the MODE switch to RECOVERY. Open the recovery cylinder vapor valve and both the low and high side valves on the manifold gauge set. Once the recovery unit's low side gauge drops below 30 psi, set the MODE switch to BYPASS.

Caution: If the MODE switch is in the BYPASS position when the low side pressure exceeds 30 psi, the recovery unit may shut down on compressor overload or high pressure cutoff.

☐ 23. Watch for the low side pressure to drop as the recovery unit shuts off automatically.

☐ 24. Close the recovery cylinder and the manifold valves.

☐ 25. If pressure rises above specified levels for the refrigerant, repeat steps 19 through 23.

☐ 26. Use the EQUALIZE switch to equalize pressure in the recovery unit.

☐ 27. Set the MODE switch to WARMUP and restart the recovery unit.

Job Sheet 2

☐ 28. Allow the recovery unit to run for one minute, and then close the OUTLET valve.

☐ 29. Wait while the unit removes the refrigerant trapped in the hoses.

☐ 30. When the recovery unit shuts down, close the INLET valve and turn the POWER switch OFF.

☐ 31. Have your instructor check your recovery procedure and service form.

☐ 32. Be sure to drain the oil trap when recovery is complete because the oil contains contaminants; use the following procedure:

Use the valve core depressor to push in the valve core in the OIL TRAP OUTLET fitting. The refrigerant pressure will push the oil through the outlet fitting. Use caution when draining the oil, but be sure to measure the approximate amount of oil removed from the system, and when you replace refrigerant in the system, be sure to add the proper amount of oil.

☐ 33. Dispose of the old oil according to local procedures.

Note: Oil disposal may mean simply putting the oil in a collection container so it can later be picked up or transported for proper disposal, but check with your instructor about local/state laws that need to be followed.

☐ 34. Secure equipment or service the recovery unit so it will be ready for the next job.

☐ 35. Return materials to proper storage areas.

Evaluator's comments: ______________________________

____

____

Job Sheet 2

Service Work Order

Customer's Name ____________________

Customer's Address ____________________

Brief description of problem ____________________

Time and date service or repair started ____________________

Time and date service or repair ended ____________________

Materials or equipment used to complete service or repair (continue list on back of form if needed) ____________________

Was refrigerant removed from system during service? ☐ Yes ☐ No
If refrigerant was removed, what was the disposition of the refrigerant removed?
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight ____________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? ____________
What amount of refrigerant was added? ____________
Were appropriate service tags left on system for future service reference? ☐ Yes ☐ No
Note: If you added refrigerant, the service tag should indicate both date and amount.

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ____________________ Date __________

Refrigerant Recovery, Recycling, and Reclaiming
Unit 15

Job Sheet 3—Use a Recovery/Recycling Machine to Recovery/Recycle Refrigerant From an AC or Refrigeration System

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Recovery/recycling machine checked and properly set up	______
Recovery cylinder checked and properly set up on scales	______
Recovery procedure properly completed	______
Recycling procedure properly completed	______
Service Form properly completed	______

A. Tools and materials

Air conditioning or refrigeration system as selected by instructor
Recovery/recycling machine and operator's guide as selected by instructor
Recovery cylinder with automatic shut-off switch
Manifold gauge set
Oil recovery container (may be with R/R unit)
Open end wrench, refrigerator service wrench, and torque wrench
Safety glasses, service form, and pen or pencil

B. Procedure

> Note: This procedure is for the ROBINAIR Model 17500B Refrigerant Recovery and Recycling Station and is reprinted with permission of the Robinair Division of SPX Corporation. Your instructor may change the procedure to facilitate available local equipment. The brand name references typical application; no endorsement is intended.

☐ 1. Make appropriate entries on the service form that accompanies this job sheet, and be sure to complete the form so it can be part of your instructor's evaluation.

☐ 2. Put on safety glasses.

Job Sheet 3

☐ 3. Check to be sure clean filter core driers are in place.

Note: if filter driers need to be replaced, follow the replacement procedure outlined later in this activity.

☐ 4. Install the refillable refrigerant cylinder with the following routine:

(a) Open either valve on the recovery cylinder to discharge the factory charge of nitrogen int he cylinder.

(b) Place the cylinder on the scale platform at the back of the R/R unit.

(c) Position the bottom lip of the cylinder around the outside diameter of the stand-off welded to the platform; this will automatically center the cylinder.

(d) Fasten the strap loosely around the cylinder to prevent it from tipping, but do not tighten the strap too tight or it could affect scale accuracy.

(e) Attach the red hose from the back of the R/R unit to a vacuum pump.

(f) Attach the blue hose from the back of the R/R unit to the blue LIQUID valve on the tank.

(g) Open the LIQUID valve on the tank.

(h) Turn on the vacuum pump and pull a vacuum on the R/R unit and the cylinder for approximately 10 minutes to remove non-condensable air and moisture from the R/R unit and the cylinder.

(i) Disconnect the hose from the vacuum pump and turn the pump off.

(j) Attach the red hose to the red VAPOR valve on the cylinder, and open the valve.

Note: When using a replacement cylinder, pull a 5-minute vacuum on the cylinder only with a separate vacuum pump and refrigerant hose.

☐ 5. Attach a manifold gauge set to the system, and if there is no pressure in the system, no refrigerant can be recovered.

☐ 6. Attach the center hose of the manifold gauge to the inlet filter on the rear of the R/R unit.

Job Sheet 3

☐ 7. Open both valves of the manifold gauge set and purge the air from the center hose of the manifold by slightly loosening the knurled connector.

☐ 8. Make sure the GAS and LIQUID valve on the recovery cylinder are both open.

☐ 9. Turn the inlet Flow Control Valve on the side of the R/R unit to the LIQUID setting.

☐ 10. Plug the R/R unit into a proper voltage AC outlet and turn the Main Power switch ON.

☐ 11. Depress the Recovery Start switch, and note that the amber recover On light comes on as the compressor starts.

☐ 12. Observe the sight glass on the side of the R/R unit; if liquid is visible, leave the Inlet Flow Control Valve on the LIQUID setting; if liquid is not visible in the sight glass, switch to the VAPOR setting.

☐ 13. Wait for the compressor to shut off automatically to indicate that recovery is complete.

☐ 14. Hold for 5 minutes and watch for a pressure rise above 0 (zero) psi, and if there is a pressure rise, repeat steps 11, 12, and 13 again.

☐ 15. Drain the oil collected from the AC system out of the R/R unit with the following routine:

(a) Open the drain valve slowly and permit the oil to flow into a collection container that is housed on the R/R unit.

(b) Close the oil drain valve after all oil has drained, and measure or estimate the amount of new refrigerant oil you will have to add to the AC system.

(c) Secure the used oil container so the oil can later be disposed of properly.

☐ 16. Watch for signs that the tank is full; the trip switch at the bottom of the weight platform will turn the compressor off, and the TANK FULL light will come on.

☐ 17. Close all valves and remove the recovery cylinder from the platform. If there is still refrigerant to be recovered from the system, a new refillable tank should be positioned properly on the scale and the recovery procedure should be continued.

Job Sheet 3

☐ 18. Check to determine if high recovery cylinder pressure brought on by a temperature increase has caused the R/R unit to shut off; if this is the case, install a new recovery cylinder or cool the recovery cylinder and continue.

With on-site recovery, ambient air temperatures are frequently high enough to cause a significant temperature rise in a recovery cylinder; at a remote site where cooling the cylinder would be difficult, a second cylinder that has been kept in a cool place should be used, and the original cylinder should be placed in a cool place so it can also be used again.

☐ 19. Prepare the R/R unit to recycle R-12 with the following routine:

(a) If the needles on the air purge indicator vary by more than 10 psi, open the Air Purge Valve until the needles coincide.

(b) Close the Air Purge Valve and check for any variation of the needles, and if the variation is more than 10 psi, repeat the routine as necessary.

☐ 20. Prepare the R/R unit to recycle R-22, R-500, or R-502 by opening the vent on the recovery vent on the R/R unit for about 5 to 10 seconds to remove any air trapped inside.

☐ 21. Start the recycling procedure by opening both valves on the recovery cylinder.

☐ 22. Make sure the MAIN POWER switch is ON.

☐ 23. Depress the Recycle Start switch to the ON position; watch for the amber Recycle On light to come on, and listen for the refrigerant pump to start.

Note: The recycling system should be operated for a minimum of 1 hour, so it is a good idea to check your watch and note the time you start recycling.

☐ 24. Look for refrigerant going through the moisture indicator as recycling starts; if there is a sufficient supply of refrigerant, approximately 15 lbs., the bubbles will clear after a few seconds.

☐ 25. Watch for bubbles to clear from the moisture indicator; if the bubbles clear, the refrigerant pump is operating at maximum efficiency; if the bubbles do not clear, check the TROUBLESHOOTING GUIDE that accompanies the equipment.

Job Sheet 3

☐ 26. Complete the following routine only if recycling R-12;

(a) After recycling for approximately 5 minutes, check the air purge indicator on the rear of the R/R unit.

(b) If the green pointer on the air purge indicator leads the red pointer by more than 10 psi (2 small divisions), bleed the bank through the air purge valve until both pointers indicate the same psi.

(c) Repeat the routine as necessary.

☐ 27. Allow the unit to operate until the dot in the center of the Moisture Indicator turns green (refer to the color indicator decal on R/R unit control panel).

☐ 28. Continue operating the recycling system until it has run for a minimum of one hour or until the color indicator dot turns green; depending on the system, refrigerant type, and operating conditions, this could take up to 3 hours.

Caution: If you are recycling refrigerant recovered from an AC system with hermetic motor burnout, run the recycling system for at least 4 hours, and test the AC system oil taken from the oil separator with an acid test kit!

☐ 29. Depress the Recycle Start switch to the OFF position.

☐ 30. Replace filter drier cores if any of the following conditions have been indicated during recovery or recycling:

(a) If the moisture indicator does not change from yellow to green after recycling for 3 hours, the filter cores are probably saturated with moisture and should be changed.

(b) If the filter cores become clogged with particulates, the filter monitor needle will register in the red zone to indicate that the filters should be changed.

(c) If the filter monitor needle registers in the red zone, the filter drier cores are clogged with particulates and should be changed.

☐ 31. Close the LIQUID valve and open the VAPOR valve on the recovery cylinder.

Note: Do not remove the filters from the cans until you are ready to install them in the R/R system.

Job Sheet 3

☐ 32. Remove the blue hose form the recovery cylinder and attach it to the recovery inlet on the R/R unit.

Caution: "De minimus" venting regulations apply to this activity!

☐ 33. Turn the Main Power Switch ON and press the Recovery Start Button.

☐ 34. Allow the R/R unit to run until the Recover On light goes out; this permits the unit to recovery refrigerant remaining in the unit and the filter.

☐ 35. Remove the 8 hex bolts holding the filter cap to the shell; the filter drier cores and brackets are attached to the filter caps.

☐ 36. Remove the 3 tie rods from the filter cap and remove the old filters from the brackets.

☐ 37. Dispose of the old filters according to prescribed procedures.

☐ 38. Clean all internal parts with a clean, dry shop cloth.

☐ 39. Remove the replacement filter core driers form their sealed cans; be sure you have 2 of them.

☐ 40. Replace the filter cap gaskets with each filter change; new gaskets are included with the filter drier cores.

☐ 41. Center the spring on the filter cap; place the upper bracket of the spring with the center boss of the bracket fitting into the coil, and the edges of the plate facing up.

Job Sheet 3

☐ 42. Position the first filter on the upper bracket nearest the cap.

☐ 43. Add the center bracket and position the second filter and gaskets on the center bracket.

☐ 44. Place the screened lower bracket on the second filter drier core and install the rods.

☐ 45. Install the filter drier core assembly into the filter shell.

☐ 46. Replace the 8 bolts and tighten them to 15 lbs. torque in an even star pattern.

☐ 47. Attach the blue hose to the vacuum pump, and evacuate for approximately 10 minutes to remove any air that entered during the filter change-out.

☐ 48. Disconnect the hose from the vacuum pump and turn the vacuum pump off.

☐ 49. Reattach the blue hose to the LIQUID port of the R/R unit tank, and then open the LIQUID valve.

☐ 50. Have your instructor check your filter drier replacement procedure.

☐ 51. Secure all equipment and return materials to proper storage areas.

Evaluator's comments: ____

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Job Sheet 3

Service Work Order

Customer's Name ______________________________

Customer's Address ______________________________

Brief description of problem ______________________________

____

____

Time and date service or repair started ______________________________

Time and date service or repair ended ______________________________

Materials or equipment used to complete service or repair (continue list on back of form if needed) ______________________________

____

____

____

Was refrigerant removed from system during service? ☐ Yes ☐ No
If refrigerant was removed, what was the disposition of the refrigerant removed?
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight ______________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? ______________
What amount of refrigerant was added? ______________
Were appropriate service tags left on system for future service reference? ☐ Yes ☐ No
Note: If you added refrigerant, the service tag should indicate both date and amount.

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ______________________ Date ____________

Evacuating, Pressurizing Leak Testing, and Charging
Unit 16

Objective Sheet

Unit Objective

After completing this unit, the student should be able to install a line tap, install a filter-drier, pressurize and leak test a refrigeration system, evacuate/triple evacuate a refrigeration system, fill a charging cylinder, vapor charge and liquid charge refrigeration systems with a charging cylinder, vapor charge with a refrigerant cylinder, and use superheat parameters to evaluate a system charge. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to evacuating, pressurizing, leak testing, and charging with their correct definitions.
2. Select true statements about preparing a refrigeration system for operation.
3. Solve problems about removing refrigerants and other gases.
4. Complete statements about guidelines for assembling components.
5. Select true statements about guidelines for pressurizing a system.
6. Solve problems about leak testing with soap solution.
7. Complete statements about leak testing with a halide torch.
8. Select true statements about why refrigeration systems require evacuation.
9. Complete statements about pressure/temperature requirements for dehydration.
10. Select true statements about the use and care of vacuum pumps.
11. Complete statements about use and care of vacuum measuring equipment.

Objective Sheet

12. Read a mercury manometer.

13. Select true statements about using/reading a micron gauge.

14. Complete statements about guidelines for evacuation.

15. Solve problems about characteristics of charging equipment.

16. Select true statements about using weight or volume to charge a system.

17. Complete statements using a sight glass for charging.

18. Respond to conditions about using a superheat table for charging.

19. Complete statements about special conditions for liquid and vapor charging.

20. State the importance of keeping charging records.

21. Complete a list of procedures for preparing a small refrigeration system for operation.

22. Complete a list of procedures for preparing a refrigeration system for operation with a thermostatic expansion valve.

23. Complete a list of procedures for preparing an air conditioning system for operation with a fixed metering device.

24. Complete Service Work Order 1. (Assignment Sheet 1)

25. Complete Service Work Order 2. (Assignment Sheet 2)

26. Complete Service Work Order 3. (Assignment Sheet 3)

27. Install a line tap access valve. (Job Sheet 1)

28. install a filter-drier on a capillary tube. (Job Sheet 2)

29. Pressurize a refrigeration system with refrigerant and dry nitrogen. (Job Sheet 3)

30. Leak check with a halide torch. (Job Sheet 4)

31. Evacuate a refrigeration system and verify level with a micron vacuum gauge. (Job Sheet 5)

32. Fill a charging cylinder. (Job Sheet 6)

Objective Sheet

33. Vapor charge a refrigeration system from a charging cylinder. (Job Sheet 7)
34. Install a thermostatic expansion valve with flare fittings. (Job Sheet 8)
35. Install a liquid indicator with flare fittings. (Job Sheet 9)
36. Install a filter-drier with flare fittings. (Job Sheet 10)
37. Pressurize a system with dry nitrogen and leak test. (Job Sheet 11)
38. Triple evacuate a refrigeration system. (Job Sheet 12)
39. Liquid charge a refrigeration system from a refrigerant cylinder. (Job Sheet 13)
40. Check and adjust a thermostatic expansion valve using superheat parameters. (Job Sheet 14)
41. Install a core-type access valve. (Job Sheet 15)
42. Install a filter-drier with sweat fittings. (Job Sheet 16)
43. Leak test a refrigeration system with an electronic leak detector. (Job Sheet 17)
44. Evacuate a refrigeration system. (Job Sheet 18)
45. Liquid charge using a charging cylinder. (Job Sheet 19)
46. Vapor charge a refrigeration system form a refrigerant cylinder. (Job Sheet 20)
47. Use suction line temperature/pressure parameters to evaluate a system charge. (Job Sheet 21)

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction or individual learning activities. Study the specific objectives to determine the order in which you will present the objectives.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan enrichment of exceptional students as well as accommodation of special needs students.
4. Add visual enhancement by making transparencies from materials that apply to the subject areas; make sure materials are copyright approved or your own products.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of the Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss and demonstrate the procedures in the assignment and job sheets, and obtain any special tools and materials required.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.

Suggested Activities

14. Compile assignment sheet ratings, job sheet ratings, and written test scores on the Unit Evaluation Form. Include any additional assignment or job sheets.

15. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These skill areas have been adapted by MAVCC.

1. This unit contains many job sheets that were saved specifically for this unit so that students would have time to acquire prerequisite skills needed to complete them. As you review and demonstrate those job sheets, you may want to integrate them with earlier job sheets where the student will have systems in a condition where many other typical service procedures can be performed. Skill areas: **Foundation skills, math and science.**

2. Demonstrate the use of a vacuum pump as you discuss Objective 5. The vacuum pump is used with many of the job sheets in this unit, and each student should have a good command of setting up a vacuum pump and the attendant service equipment than can be used with a vacuum pump. Skill areas: **Foundation skills, math and science.**

3. Arrange with a local service company for groups of students to accompany local technicians who will be evacuating, pressurizing, and leak testing systems in their service work. Plan this far enough in advance that students can prepare notes about questions they want to ask on the job site. Have students report to the class about the type of equipment the technician was using, the procedure used, and the general conduct of evacuating, pressurizing, and leak testing in a real-world situation. Skill areas: **Group effectiveness skills, teamwork.**

4. Note that Job Sheet 4 involves lighting and using a halide torch for detecting leaks. This is an optional job sheet because the torch can pose safety problems when improperly used. However, because the halide torch is still the least expensive and still an effective way to search for halide-based refrigerant leaks, it is a tool that technicians need to learn to use. Skill areas: **Foundation skills, math and science.**

Resources Used in Developing This Unit

1. Killinger, Jerry and LaDonna Killinger. *Heating and Cooling Essentials*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1993.

Suggested Activities

2. *Part II Environmental Protection Agency, 40 CFR Part 82, Protection of Stratospheric Ozone; Refrigerant Recycling; Final Rule.* Washington, DC: Environmental Protection Agency, 1993.

3. *Refrigerant Containment Applicant Study Guide.* Arlington, TX: Video General, Inc., 1994.

4. *Refrigerant Transition and Recovery Certification Program for HVAC/R Technicians.* Washington, DC: Air Conditioning Contractors of America, 1994.

5. *The Air Conditioning, Heating, and Refrigeration News HVAC/R Source Guide.* Troy, MI: Business News Publishing Company, 1994, 1995.

6. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

The *Federal Register* of Friday, May 14, 1993, contains Part II of 40 CFR and covers the intricate details of recovery, recycling, and reclaiming, including Table 1 concerning recovery levels, and Table 2 which shows standards for recovery and recycling equipment. Because it does detail many regulations that affect routine ACR service, it is a vital reference for instructors. For ordering information, contact the Stratospheric Ozone Information hotline at 1-800-296-1996.

Instructions for Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Suggested Activities

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.

3 - Moderately skilled—Has performed job during training program; limited additional training may be required.

2 - Limited skill—Has performed job during training program; additional training is required to develop skill.

1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Answers to Assignment Sheets

Assignment Sheet 1

Evaluate with criteria from associated job sheets.

Assignment Sheet 2

Evaluate with criteria from associated job sheets.

Assignment Sheet 3

Evaluate with criteria from associated job sheets.

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Answers to Written Test

1. a. 6
   b. 3
   c. 7
   d. 9
   e. 1
   f. 5
   g. 10
   h. 8
   i. 2
   j. 4

2. a, b, d, e, f

3. a. (2)
   b. (2)

4. a. maximum
   b. brazing
   c. moisture
   d. liquid, liquid
   e. suction
   f. final (or last)
   g. restrictions

5. a, b, c, e, g, h, j

6. a. (2)
   b. (2)

7. a. HCFC-22 (or R-22)
   b. copper
   c. flexible
   d. heavier

8. a, b, c, d, e, g, h

9. a. vaporized
   b. lowering
   c. hair
   d. defrost
   e. below
   f. microns
   g. H_2O (or water)
   h. coldest

10. a, b, c, f, g

Answers to Written Test

11. a. The most commonly used
    b. 28" or 29" hg
    c. 29.8" hg
    d. vertical
    e. below
    f. thermocouple

12. 29.72" hg

13. a, b, d

14. a. integrity, integrity
    b. center
    c. vaporize
    d. vacuum
    e. tee
    f. high, low
    g. double, triple
    h. dehydrated
    i. coolest
    j. nitrogen
    k. 15
    l. microns
    m. 15

15. a. In the smallest increments.
    b. The level of the clear tube that runs up the side of the cylinder.
    c. Vapor charge form the top valve, liquid charge from the bottom valve.
    d. A customer.

16. b, d, e, f

17. a. metering device
    b. low on refrigerant
    c. liquid

18. a. (2)
    b. (2)

19. a. low
    b. low
    c. liquid
    d. very time consuming

Answers to Written Test

20. Answer should include, at a minimum, the following:

Good records build a life history of a system so service can be accomplished faster, better, and at less expense to the customer.

For additional points, the answer may include:

Good records build image and prestige for a company.

21. a. tap access
b. capillary
c. R-22
d. halide
e. micron
f. cylinder
g. Vapor
h. service work order

22. a. thermostatic
b. sight
c. filter-drier
d. nitrogen
e. Triple
f. Liquid
g. superheat
h. service work order

23. a. core-type
b. sweat
c. dry
d. electronic
e. manometer
f. charging
g. Vapor
h. suction
i. service work order

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Written Test

Name ______________________ Date ______________ Score ______

1. Match the terms on the right with their correct definitions.

_____a. A small brush used for applying flux or liquid leak testing detergent

_____b. Any device which uses a Class I or Class II substance as a refrigerant and which is used for household or commercial purposes, including any air conditioner, refrigerator, chiller, or freezer, except that used for military purposes

_____c. That part of an evacuation procedure that removes air and other non-condensable gases from a refrigeration system

_____d. That part of an evacuation procedure that removes moisture from a refrigeration system

_____e. Oil pumped nitrogen in a pressurized cylinder, used for pressurizing a refrigeration system for leak testing or sweeping system lines during certain soldering or brazing activities

_____f. The removal of non-condensable gases, moisture, and oil-entrapped refrigerant from an appliance

_____g. Mechanical vapor compression refrigeration equipment used to cool the driver's or passenger's compartment of a motor vehicle

1. Dry nitrogen
2. Nitrogen regulator
3. Appliance
4. Small appliance
5. Evacuation
6. Acid brush
7. Degassing
8. MVAC-like appliance
9. Dehydrating
10. MVAC

Written Test

______h. Mechanical vapor compression, open-drive compressor appliances used to cool the driver's or passenger's compartment of a non-road vehicle, including agricultural and construction vehicles

______i. A metering device used to reduce high nitrogen pressure to a safe, low working pressure

______j. A refrigeration product fully manufactured, charged, and hermetically sealed with five pounds or less of refrigerant in a factory

2. Select true statements about steps in preparing a refrigeration system for operation. Place an "X" beside each true statement.

______a. Preparing a new system for initial operation or preparing an older system for operation requires that assembly or repairs be made without danger to personnel, equipment, or the environment.

______b. On a new or repaired system, the first step in preparing the system for operation is to verify that no refrigerant or other gases are present in the system or any portion of the system being worked on, or to remove any refrigerant that may be in the system.

______c. Pressurize the system for leak testing with dry nitrogen only.

______d. Leak test the system to assure that refrigerant will not escape from the system and that air or other matter cannot enter the system.

______e. Evacuate the system to assure that it is dehydrated, free of all moisture, and degassed, free of air or other gases.

______f. Charge the system with the proper amount of the refrigerant specified by the equipment manufacturer or a suitable alternative if the system has been retrofitted.

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Written Test

3. Solve problems about removing refrigerant and other gases. Circle the number in front of the statement that best solves each of the following problems.

   a. Your coworker is working on a system that is suspected of having refrigerant entrapped in the oil. The coworker knows that the system will have to be evacuated, but the problem is, how deep does it have to be evacuated?

      (1) Evacuate to at least 18″ hg.

      (2) Evacuate to at least 28″ hg.

   b. You have been given a component to install on a new system, and you know the component is pressurized with nitrogen, and you have to decide whether to try to recover the nitrogen or simply vent it to atmosphere.

      (1) Nitrogen is as expensive as most refrigerants, so recover it.

      (2) Vent the nitrogen to atmosphere; de minimus venting does not reply to nitrogen charges.

4. Complete statements about guidelines for assembling components. Write in the missing material needed to complete each of the following statements.

   a. Whether new or under repair, the components of a system must be properly assembled to assure proper operation and __________________ efficiency.

   b. Proper assembly is accomplished through mechanical means by using flare, quick-connect, or compression fittings, or by soldering or __________________.

   c. Take special care not to introduce any foreign substance or excess __________________ into the system.

   d. Add a __________________ line drier to a new system or replace the __________________ line drier after a system has been opened to the atmosphere.

   e. Add a __________________ line drier when extra protection is needed or desired for the compressor; adding a __________________ line drier is essential after a burnout.

   f. Make the drier the __________________ connection in the assembly so that it will be exposed to the atmosphere no longer than necessary.

Written Test

g. Take special care to create no ________________ with tight bends or kinks in tubing, excess brazing materials, or the improper connection of fittings.

5. Select true statements about guidelines for pressurizing a system. Place an "X" beside each true statement.

______a. Once refrigerant has been removed from a system and the system has been assembled or repaired, the system must be pressurized for leak testing.

______b. Attach a gauge manifold set to the system and attach the center hose from the manifold gauge set to a cylinder of HCFC-22.

______c. Give the system a preliminary charge to about 5 psig of HCF-22, if you intend to leak test with a halide torch or an electronic leak detector.

______d. Use oxygen or compressed air for pressurizing only as a last resort.

______e. Use a pressure regulator between the high pressure nitrogen or CO_2 and the system.

______f. Hook up the manifold gauge set compound gauge hose to the outlet of the inert gas cylinder.

______g. Close the pressure regulator valve and open the valve on the inert gas cylinder.

______h. Slowly open the regulator valve until it indicates the system pressure recommended for pressurizing.

______i. Open the low side valve on the manifold gauge set.

______j. Keep the pressure at the recommended level while leak testing the system.

6. Solve problems for leak testing with soap solution. Circle the number in front of the statement that best solves each of the following problems.

a. You notice another technician starting to leak test a system with soap bubbles, and the technician starts by applying a detergent solution to a point on the suction line. There seems to be no problem, but there could be a problem because:

(1) The technician needs to start at the nearest or farthest point in the system and work back to it.

(2) The technician needs to leak test the manifold gauge set first because once it is hooked up it becomes part of the system, and if it is leaking and not properly check it could provide misleading information.

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b. You know a system is suspect of having a leak, but you don't know exactly where to start testing. To solve the problem you should probably:

(1) Pick any point, start leak check there, and then return to the point; then do everything a second time to be sure.

(2) Look for oil around any point in the system; this is a common clue that there is probably a leak at or near that point.

7. Complete statements about leak testing with a halide torch. Write in the material that best completes each of the following statements.

a. For a halide torch to work as a leak detector, the system has to be charged with a mixture of nitrogen and ________________.

b. A halide torch is ready for leak testing when the ________________ element heats up.

c. When using a halide torch, you actually "sniff" for leaks with a ________________ hose attached to the unit.

d. Always keep the halide "sniffer" below the spot of a suspected leak because refrigerant is ________________ than air.

8. Select true statements about why refrigeration systems require evacuation. Place an "X" beside each true statement.

______a. Through leaks, improper charging, or during repairs, moisture and noncondensable gases can enter a refrigeration system and accelerate system wear, cause poor performance, and lead to system breakdown.

______b. A major objective of evacuation is to dehydrate the system, to take all the moisture out of the system to keep it from causing compressor damage or causing ice crystals to form at the evaporator and stop system operation.

______c. Getting moisture out of the system prevents moisture form combining with refrigerants to form both hydrochloric and hydrofluoric acids which accelerate wear on all metal parts, especially compressors.

______d. Removing moisture also prevents the creation of sludge which forms when a mixture of refrigerant oil and moisture is heated.

Written Test

______e. Another major objective of evacuation is to degass the system, to remove noncondensable gases, especially air, from the system to help avoid accelerated corrosion, acid formation, and sludge that can damage a compressor and diminish system efficiency.

______f. Air in a system should be removed, but a small amount of air will not decrease performance.

______g. Still another objective of evacuation is to remove refrigerant that can become entrapped in the oil.

______h. Evacuation properly accomplished prepares a system for pressurizing, leak testing, and charging with reasonable assurance that the system will operate leak-free at maximum efficiency.

______i. Evacuation should not be used as a means of checking a system for leaks.

9. Complete statements about pressure/temperature requirements for dehydration. Write in the word(s) that best completes each of the following statements.

   a. Water cannot be removed from a system in liquid form so it has to be __________________ before it can be removed.

   b. Evaporation can be accomplished by heating the system or portions of the system or by __________________ the pressure to an evaporation point, or both.

   c. A common __________________ drier can be used to heat a coil, and in a combination heating/cooling unit, the heater can be used to raise coil temperature.

   d. In a commercial refrigeration system, heating can be accomplished by energizing the __________________ cycle, if the system uses electric defrost.

   e. Evacuating the system to a sufficient level __________________ atmospheric pressure will lower the boiling or evaporation point of water in the system to the temperature of the system itself.

   f. To measure pressures below atmospheric pressure, or zero psig, use inches of mercury, "hg, millimeters of mercury, mm hg, or __________________.

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Written Test

g. Knowing the evaporation temperature of __________________ at various pressures is essential to proper dehydration, and a good vacuum/temperature chart will have the information.

h. Once the temperature of the system, or the temperature of the __________________ part of the system has been measured, that temperature can be located on the chart and guide a technician to the desired evacuation level.

10. Select true statements about use and care of vacuum pumps. Place an "X" beside each true statement.

______a. Evacuation is accomplished with a vacuum pump rated as a high- or a low-vacuum pump depending on the depth of vacuum it can pull.

______b. A low-vacuum pump is a single-stage pump, usually a hermetic type, and rated at 1 cfm or less.

______c. A high-vacuum pump is generally a two-stage pump, may have a direct-coupling drive or be driven by a belt, and is rated at 1 to 5 cfm.

______d. To assure long life of a vacuum pump, change the pump oil after every third or fourth evacuation.

______e. When not in use, keep caps on the outlet and inlet ports, and discharge refrigerant through an evacuation pump very slowly.

______f. To check the operation of a vacuum pump, see how deep a vacuum the pump can pull on itself; a low-vacuum pump should pull 29″ hg, and a high-vacuum pump should pull a vacuum of 100 microns.

______g. The amount of time it takes to reach the required vacuum is related to both pump displacement and the size of the connecting line between the pump and the system.

11. Complete statements about use and care of vacuum measuring equipment. Circle the material that best completes each of the following statements.

a. (**A frequently used**) (**The most commonly used**) piece of equipment for measuring a vacuum is the compound gauge on a technician's manifold gauge set.

b. The compound gauge can accurately measure a vacuum to (**28″ or 29″ hg**) (**29.9″ hg**), but there are service situations where the compound gauge should not be used as the sole indicator of the level of vacuum.

Written Test

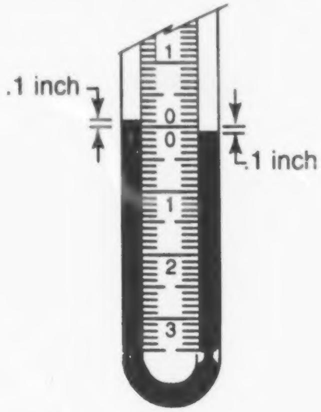
c. Because of its affordability, a mercury manometer is still used by many ACR technicians for vacuum measurements, and it can accurately record vacuum levels to (**29.8" hg**) (**30.0" hg**).

d. Be sure to cap a mercury manometer when it is not in use, and use and store it in a (**vertical**) (**horizontal**) position.

e. Vacuums (**below**) (**above**) 29.8" hg should be measured in microns, and this is accomplished with a micron gauge.

f. Micron gauges are either of a (**thermocouple**) (**thermometer**) type or electronic, but in either case, they are expensive and should be handled with care.

12. Read a mercury manometer. Examine the manometer in the following illustration and indicate in inches of mercury the depth of vacuum it shows.



Answer ____________________

13. Select true statements about using/reading a micron gauge. Place an "X" beside each true statement.

______a. A micron gauge is an electronic instrument used to measure vacuum, and is popular because it is small and can be hooked up directly to the system or to a vacuum pump.

______b. Some micron gauges are hand-held and require no auxiliary power because they have an on-board battery.

______c. To read a micron gauge, hook it up, turn it on, and check the color-coded LED display for the vacuum level; it will record effectively form 5,000 microns to 2,000 microns.

______d. Keep the micron gauge in its cover in a secure spot in your tool kit when it is not in use because it is an expensive instrument.

Written Test

14. Complete statements about guidelines for evacuation. Write in the word(s) that best completes each of the following statements.

    a. Evacuation of a system should not begin until the ________________ of the system has been verified; verifying system ________________ means leaks have been repaired, the system has been pressurized and leak tested, and the pressurizing gas has been removed.

    b. Attach a manifold gauge set to the system with the ________________ hose attached to the evacuation equipment.

    c. Measure the temperature of the system, and use a vacuum table to determine the vacuum required to ________________ the moisture in the system.

    d. Measure system ________________ with a mercury manometer or a micron gauge.

    e. If a manifold gauge set is attached to both the high and low sides of the system and you want a verifying vacuum measurement from a micron gauge or a manometer, use a ________________ off one of the service ports to make the hook up.

    f. Begin evacuation through the ________________ side of the system until you reach 5" hg, and then evacuate through the ________________ side.

    g. If the evacuation equipment will not permit a deep evacuation to at least 500 microns, you should ________________ or ________________ evacuate the system, and the system may also require warming.

    h. If you reach a level of 500 microns, continue to evacuate for at least 20 minutes more to assure that the system is completely degassed and ________________.

    i. In all cases, the vacuum level must be low enough to vaporize moisture at the temperature of the ________________ part of the system.

    j. To assure that moisture levels are reduced to acceptable levels, use double or triple evacuation and insert dry ________________ after each evacuation.

Written Test

k. After reaching a final vacuum it is good procedure to allow the system to stand for at least ____________________ minutes to verify that there are no leaks or moisture present.

l. If the vacuum level changes more than a few hundred ____________________, the system probably still contains moisture or a leak is allowing air to enter the system; the evacuation procedure has to be repeated.

m. If the vacuum holds for at least ____________________ minutes, the system is ready for charging.

15. Solve problems about characteristics of charging equipment. Write the solutions to each of the following problems.

a. If you had to select a proper charging cylinder for a job, you would definitely select one for the refrigerant you will be using, but you would also want a cylinder that would permit you to read weight in what increments?

Answer: ____

b. You know that a charging cylinder has to be filled to an exact amount, but how do you monitor the amount?

Answer: ____

c. The rules about vapor and liquid charging from a charging cylinder say what with respect to the top and bottom cylinder valves?

Answer: ____

d. Scales used to measure refrigerant must be approved because the scales will be used to determine the cost to whom?

Answer: ____

16. Select true statements about using weight or volume to charge a system. Place an "X" beside each true statement.

______a. If you can determine the exact weight of the refrigerant required, the most accurate method for charging a system is by volume.

______b. The weight of the required refrigerant charge should be available on the system data plate or in the manufacturer's installation instructions.

_____c. For small appliances or package-type systems that hold 5 pounds of refrigerant or less, the most accurate method of charging is by weight using a set of scales.

_____d. The volume charging method with a charging cylinder can also be used for small split systems if you can determine the exact amount of refrigerant required.

_____e. When a charging cylinder is not available, a refrigerant charge should be weighed on a good set of mechanical or digital scales; in fact, some digital scales measure within a tenth of a pound.

_____f. Whether charging by weight or by volume, keep records for customer billing and EPA requirements, and tag the equipment with service information that service technicians can reference in the future.

17. Complete statements about using a sight glass for charging. Write in the word(s) that best complete each of the following statements.

    a. On systems with a thermostatic-type expansion valve, the sight glass shows the condition of the refrigerant reaching the _________________ _________________.

    b. When a sight glass or liquid indicator shows bubbles, it means the system is _________________ _________________.

    c. When using a sight glass or liquid indicator, the system is usually properly charged when the bubbles in the indicator turn to _________________.

18. Respond to conditions about charginging with a superheat charging chart. Circle the number in front of the answer that presents the best response to each of the following conditions.

    a. About the only time you might resort to using a superheat charging table is when:

        (1) The manufacturer's charging guidelines are not available.

        (2) The system has a capillary tube and you can find no charging guidelines.

        (3) You know the system holds less than a 5 lb. charge.

b. To use a superheat charging table effectively you have to be able to:

   (1) Measure ambient temperature at the condenser.

   (2) Measure ambient temperatures at the condenser and the suction line, and also measure pressure at the suction line.

   (3) Measure ambient temperature at the suction line first and then at the condenser.

19. Complete statements about special considerations for liquid and vapor charging. Circle the material that best completes each of the following statements.

   a. Adding refrigerant to a system which already contains some refrigerant is almost always accomplished with a vapor charge fed into the (**low**) (**high**) pressure side of the system while the system is running.

   b. Take care to never add liquid refrigerant to the (**low**) (**high**) side of a system; the liquid can severely damage or ruin the compressor.

   c. Refrigerant can be added to the system in (**liquid**) (**vapor**) form through the liquid line by using a charging cylinder.

   d. Without a charging cylinder, liquid charging is (**very time consuming**) (**too fast for safe monitoring**), and if attempted at all, should be done with extreme caution.

20. State the importance of keeping charging records. In your own words, what do good records accomplish for a company?

Answer: ____

____

____

____

____

____

____

____

Written Test

21. Complete a list of procedures for preparing a small refrigeration system for operation. Write in the information needed to complete each of the following requirements.

    a. Install a line ________________ ________________ valve.

    b. Install a filter-drier on a ________________ tube.

    c. Pressurize a system with ________________ and dry nitrogen.

    d. Use a ________________ torch to check for leaks.

    e. Evacuate a system and verify level with a ________________ vacuum gauge.

    f. Fill a charging ________________.

    g. ________________ charge a system from a charging cylinder.

    h. Make appropriate entries on a ________________ ________________ ________________.

22. Complete a list of procedures for preparing a refrigeration system for operation with a thermostatic expansion valve. Write in the information needed to complete each of the following requirements.

    a. Install a ________________ expansion valve with flare fittings.

    b. Install a ________________ glass with flare fittings.

    c. Install a ________________-________________ with flare fittings.

    d. Pressurize a system with dry ________________ and leak test.

    e. ________________ evacuate a refrigeration system.

    f. ________________ charge a refrigeration system from a refrigerant cylinder.

    g. Check and adjust a thermostatic expansion valve using ________________ parameters.

    h. Make appropriate entries on a ________________ ________________ ________________.

Written Test

23. Complete a list of procedures for preparing an air conditioning system for operation with a fixed metering device. Write in the information needed to complete each of the following requirements.

    a. Install a ________________ expansion valve with flare fittings.

    b. Install a filter-drier with ________________ fittings.

    c. Pressurize a system with R-22 and ________________ nitrogen.

    d. Leak test a refrigeration system with an ________________ leak detector.

    e. Evacuate a system and verify vacuum level with a mercury ________________.

    f. Liquid charge using a ________________ cylinder.

    g. ________________ charge a refrigeration system from a refrigerant cylinder.

    h. Use ________________ line pressure/temperature parameters to evaluate a system charge.

    i. Make appropriate entries on a ________________ ________________ ________________.

    Note: For the convenience of evaluation, the service work order for these procedures is presented as an activity in Assignment Sheet 3.

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*Permission to duplicate this test is granted.

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Complete Service Work Order 1 Rating ______

Comments: ____

____

Assignment Sheet 2—Complete Service Work Order 2 Rating ______

Comments: ____

____

Assignment Sheet 3—Complete Service Work Order 3 Rating ______

Comments: ____

____

Job Sheet 1—Install a line tap access valve Rating ______

Comments: ____

____

Job Sheet 2—Install a Filter-Drier on a Capillary Tube Rating ______

Comments: ____

____

Job Sheet 3—Pressurize a Refrigeration System With Refrigerant and Dry Nitrogen Rating ______

Comments: ____

____

Job Sheet 4—Leak Check With a Halide Torch Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 5—Evacuate a Refrigeration System and Verify Level With a Micron Vacuum Gauge Rating ______

Comments: ____

____

Job Sheet 6—Fill a Charging Cylinder Rating ______

Comments: ____

____

Job Sheet 7—Vapor Charge a Refrigeration System From a Charging Cylinder Rating ______

Comments: ____

____

Job Sheet 8—Install a Thermostatic Expansion Valve With Flare Fittings Rating ______

Comments: ____

____

Job Sheet 9—Install a Liquid Indicator With Flare Fittings Rating ______

Comments: ____

____

Job Sheet 10—Install a Filter-Drier With Flare Fittings Rating ______

Comments: ____

____

Job Sheet 11—Pressurize a System With Dry Nitrogen and Leak Test Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 12—Triple Evacuate a Refrigeration System Rating ______

Comments: ____

____

Job Sheet 13—Liquid Charge a Refrigeration System From a Refrigerant Cylinder Rating ______

Comments: ____

____

Job Sheet 14—Check and Adjust a Thermostatic Expansion Using Superheat Parameters Rating ______

Comments: ____

____

Job Sheet 15—Install a Core-Type Access Valve Rating ______

Comments: ____

____

Job Sheet 16—Install a Filter-Drier With Sweat Fittings Rating ______

Comments: ____

____

Job Sheet 17—Leak Test a Refrigeration System With an Electronic Leak Detector Rating ______

Comments: ____

____

Job Sheet 18—Evacuate a Refrigeration System and Verify Vacuum Level With a Mercury Manometer Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 19—Liquid Charge Using a Charging Cylinder Rating ______

Comments: ____

____

Job Sheet 20—Vapor Charge a Refrigeration System
From a Refrigerant Cylinder Rating ______

Comments: ____

____

Job Sheet 21—Use Suction line Temperature/Pressure
Parameters to Evaluate a System Charge Rating ______

Comments: ____

____

Other ____

____

Written Tests: Pretest ______ Posttest ______

Total ______

Teacher Signature ______________________ Date ____________

Student Signature ______________________ Date ____________

*Permission to duplicate this form is granted.

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Information Sheet

1. **Terms and definitions**

    a. **Acid brush** — A small brush used for applying flux or liquid leak testing detergent

    b. **Appliance** — Any device which uses a Class I or Class II substance as a refrigerant and which is used for household or commercial purposes, including any air conditioner, refrigerator, chiller, or freezer, except that used for military purposes

    c. **Degassing** — That part of an evacuation procedure that removes air and other non-condensable gases from a refrigeration system

    d. **Dehydrating** — That part of an evacuation procedure that removes moisture from a refrigeration system

    e. **Dry nitrogen** — Oil pumped nitrogen in a pressurized cylinder, used for pressurizing a refrigeration system for leak testing or sweeping system lines during certain soldering or brazing activities

    f. **Evacuation** — The removal of non-condensable gases, moisture, and oil-entrapped refrigerant from an appliance

    g. **MVAC** — Mechanical vapor compression refrigeration equipment used to cool the driver's or passenger's compartment of a motor vehicle

    h. **MVAC-like appliance** — Mechanical vapor compression, open-drive compressor appliances used to cool the driver's or passenger's compartment of a non-road vehicle, including agricultural and construction vehicles

    i. **Nitrogen regulator** — A metering device used to reduce high nitrogen pressure to a safe, low working pressure

    j. **Small appliance** — A refrigeration product fully manufactured, charged, and hermetically sealed with five pounds or less of refrigerant in a factory

2. **Steps in preparing a refrigeration system for operation**

    a. Preparing a new system for initial operation or preparing an older system for operation requires that assembly or repairs be made without danger to personnel, equipment, or the environment.

Information Sheet

b. On a new or repaired system, the first step in preparing the system for operation is to verify that no refrigerant or other gases are present in the system or any portion of the system being worked on, or to remove any refrigerant that may be in the system.

c. Pressurize the system for leak testing with dry nitrogen or nitrogen/R-22 mixture; the presence of R-22 permits the use of a halide-type leak detector.

d. Leak test the system to assure that refrigerant will not escape from the system and that air or other matter cannot enter the system.

e. Evacuate the system to assure that it is dehydrated, free of all moisture, and degassed, free of air or other gases.

f. Charge the system with the proper amount of the refrigerant specified by the equipment manufacturer or a suitable alternative if the system has been retrofitted.

3. Removing refrigerant or other gases

a. If any refrigerant is present in a system being repaired, or in the portion of the system that is being worked on, EPA regulations require that the refrigerant be properly removed.

b. Refrigerant recovery may be accomplished with a pump down cycle or with equipment designed for recovery.

c. EPA regulations require evacuation to specific levels based on the type of equipment and other conditions.

d. Evacuating a system to at least 28″ hg will help to pull out any refrigerant entrapped in the oil.

e. When new components are pressurized with nitrogen, it is permissible to vent the nitrogen into the air.

Caution: Applying a torch to a pressurized system can be extremely dangerous to personnel and equipment.

4. Guidelines for assembling components

a. Whether new or under repair, the components of a system must be properly assembled to assure proper operation and maximum efficiency.

Information Sheet

b. Proper assembly is accomplished through mechanical means by using flare, quick-connect, or compression fittings, or by soldering or brazing.

   Note: Most codes require refrigeration lines to be brazed instead of soft soldered.

c. Take special care not to introduce any foreign substance or excess moisture into the system.

d. Add a liquid line drier to a new system or replace the liquid line drier after a system has been opened to the atmosphere.

e. Add a suction line drier when extra protection is needed or desired for the compressor; adding a suction line drier is essential after a burnout.

f. Make the drier the final connection in the assembly so that it will be exposed to the atmosphere no longer than necessary.

g. Take special care to create no restrictions with tight bends or kinks in tubing, excess brazing materials, or the improper connection of fittings.

5. Guidelines for pressurizing a system

a. Once refrigerant has been removed from a system and the system has been assembled or repaired, the system must be pressurized for leak testing.

b. Attach a gauge manifold set to the system and attach the center hose from the manifold gauge set to a cylinder of HCFC-22.

   Note: If you intend to leak test with soap bubbles, the HCFC-22 is not needed and you can skip some of the following steps.

c. Give the system a preliminary charge to about 5 psig of HCF-22, if you intend to leak test with a halide torch or an electronic leak detector.

   Note: Actually, the HCFC-22 charge should be about 10% of the total pressure of the charge, and since the EPA does not consider the HCFC-22 as a part of system refrigerant, it can later be vented to the atmosphere along with the nitrogen.

d. Use dry nitrogen or carbon dioxide as an inert gas for pressurizing, but never use oxygen or compressed air for pressurizing.

e. Use a pressure regulator between the high pressure nitrogen or CO_2 and the system.

f. Hook up the manifold gauge set center hose to the outlet of the inert gas cylinder.

Information Sheet

g. Close the pressure regulator valve and open the valve on the inert gas cylinder.

h. Slowly open the regulator valve until it indicates the system pressure recommended for pressurizing.

Note: Pressurizing pressure varies with system size and the refrigerant used; with R-12, recommended pressures range from 100 lbs. to 150 lbs., and for R-22 systems, recommended pressures range from 150 to 300 lbs.

i. Open the high side valve on the manifold gauge set.

j. Keep the pressure at the recommended level while leak testing the system.

6. Leak testing with soap solution

a. After a system has been pressurized with only nitrogen, use a bubble leak detecting fluid because a halide torch or an electronic detector will not react to nitrogen.

b. For leak testing air conditioning where there are no problems with freezing, brush on a commercial leak detecting fluid, a diluted household detergent, or an inexpensive kid's bubble solution.

Note: A limitation of leak testing with bubbles is that it will not detect really small leaks, but some commercial leak testing fluid is good at detecting small leaks.

Information Sheet

c. For leak testing refrigeration, use a commercial grade leak detecting fluid that contains antifreeze and a wetting agent which makes it cling better; good detecting fluid is noncorrosive, but all leak test fluid should be wiped off after use.

d. Apply bubble leak detecting fluid with a soft acid brush or spray it on; look for big bubbles to indicate large leaks, small bubbles to indicate small leaks.

e. Start by leak testing the manifold gauge set and all the hoses that are part of it because when the manifold gauge set is hooked up it becomes part of the system.

f. Look for leaks around all fittings and connections, in both the evaporator and condenser coil, and for any signs of oil around any part of the system; this is a common clue that you have found a leak.

g. Mark leak locations so you can make needed repairs.

h. Vent the nitrogen charge to the atmosphere.

7. **Leak testing with a halide torch**

   a. Because of its effective performance and low cost, the halide torch is a traditional tool for leak testing systems that have not had the refrigerant removed, or systems that have been pressurized with a mixture of nitrogen and HCFC-22.

Information Sheet

b. The leak-testing torch has a circular windshield with a viewing window that gives full sight of the copper element that has to be heated for the torch to work; the torch screws onto any small, fuel gas cylinder.

c. Leak testing can be conducted with any kind of fuel gas, propane, butane MAPP® gas, FS-2, or several others; when the copper element heats up, the torch is ready for business.

d. A flexible hose is attached to the torch unit so it can be used to "sniff" for leaks at any system location where a leak is suspected; it also permits the torch flame to be pointed safely away from the system.

e. Remember that refrigerant is heavier than air, so keep the end of the sniffing hose below the spot of the suspected leak.

f. When even a tiny amount of halide reaches the heated copper element, the clear-looking flame will present a definite change of color to indicate a leak.

8. **Why refrigeration systems require evacuation**

a. Through leaks, improper charging, or during repairs, moisture and noncondensable gases can enter a refrigeration system and accelerate system wear, cause poor performance, and lead to system breakdown.

b. A major objective of evacuation is to dehydrate the system, to take all the moisture out of the system to keep it from causing compressor damage or causing ice crystals to form at the evaporator and stop system operation.

c. Getting moisture out of the system prevents moisture form combining with refrigerants to form both hydrochloric and hydrofluoric acids which accelerate wear on all metal parts, especially compressors.

d. Removing moisture also prevents the creation of sludge which forms when a mixture of refrigerant oil and moisture is heated.

Information Sheet

e. Another major objective of evacuation is to degass the system, to remove noncondensable gases, especially air, from the system to help avoid accelerated corrosion, acid formation, and sludge that can damage a compressor and diminish system efficiency.

f. Air in a system can take up condenser space needed for refrigerant, and this increases discharge pressure and decreases performance.

g. Still another objective of evacuation is to remove refrigerant that can become entrapped in the oil.

h. Evacuation properly accomplished prepares a system for pressurizing, leak testing, and charging with reasonable assurance that the system will operate leak-free at maximum efficiency.

i. Evacuation can also be used as a means of checking a system for leaks by keeping the system under vacuum for a specific period of time.

9. Pressure/temperature requirements for dehydration

a. Water cannot be removed from a system in liquid form so it has to be vaporized before it can be removed.

b. Evaporation can be accomplished by heating the system or portions of the system or by lowering the pressure to an evaporation point, or both.

c. A common hair drier can be used to heat a coil, and in a combination heating/cooling unit, the heater can be used to raise coil temperature.

d. In a commercial refrigeration system, heating can be accomplished by energizing the defrost cycle, if the system uses electric defrost.

e. Evacuating the system to a sufficient level below atmospheric pressure will lower the boiling or evaporation point of water in the system to the temperature of the system itself.

f. To measure pressures below atmospheric pressure, or zero psig, use inches of mercury, "hg, millimeters of mercury, mm hg, or microns.

g. Knowing the evaporation temperature of H_2O at various pressures is essential to proper dehydration, and a good vacuum/temperature chart will have the information.

Information Sheet

PRESSURE VACUUM EQUIVALENTS

Absolute Pressure above zero base		Vacuum below one atmosphere		Approximate fraction of one atmos.	Vaporization Temperature of H_2O in F @ each press.
microns	PSIA	mm Hg	Inches of mercury		
0	0	760.00	29.921	—	—
50	.001	759.95	29.92	1/1500	–50
100	.002	759.90	29.92	1/7600	–40
150	.003	759.85	29.92	1/5100	–33
200	.004	759.80	29.91	1/3800	–28
300	.006	759.70	29.91	1/2500	–21
500	0.01	759.50	29.90	1/1500	–12
1,000	.019	759.00	29.88	1/760	1
2,000	.039	758.00	29.84	1/380	15
4,000	0.077	756.00	29.76	1/190	29
6,000	.116	754.00	29.69	1/127	39
10,000	.193	750.00	29.53	1/76	52
15,000	.290	745.00	29.33	1/50	63
20,000	.387	740.00	29.13	1/38	72
30,000	.580	730.00	28.74	1/25	84
50,000	.967	710.00	27.95	1/15	101
100,000	1.93	660.00	25.98	2/15	125
200,000	3.87	560.00	22.05	1/4	152
500,000	9.67	260.00	10.24	2/3	192
760,000	14.696	0	0	1 Atmos.	212

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h. Once the temperature of the system, or the temperature of the coldest part of the system has been measured, that temperature can be located on the chart and guide a technician to the desired evacuation level.

Example: On an AC system with an indoor temperature of 75°F and an outdoor temperature of 90°F, the lowest temperature of 75°F will be between 72° and 84° as shown under the "Vaporization Temperature" column on the chart. We know that the deeper the vacuum, the faster the vaporization, so we would read across the chart from right to left to find that a vacuum of approximately 29" hg or 740mm hg, or 20,000 microns will effectively vaporize moisture from the system. Any vacuum below the 20,000 micron level would be acceptable because it would speed up the evaporization rate.

10. **Use and care of vacuum pumps**

a. Evacuation is accomplished with a vacuum pump rated as a high- or a low-vacuum pump depending on the depth of vacuum it can pull.

Information Sheet

b. A low-vacuum pump is a single-stage pump, usually a hermetic type, and rated at 1 cfm or less.

c. A high-vacuum pump is generally a two-stage pump, may have a direct-coupling drive or be driven by a belt, and is rated at 1 to 5 cfm.

d. To assure long life of a vacuum pump, change the pump oil after every major evacuation, or as recommended by the manufacturer.

e. When not in use, keep caps on the outlet and inlet ports, and do not discharge refrigerant through an evacuation pump.

f. To check the operation of a vacuum pump, see how deep a vacuum the pump can pull on itself; a low-vacuum pump should pull 29" hg, and a high-vacuum pump should pull a vacuum of 100 microns.

Note: Deep vacuums should be measured in microns.

g. The amount of time it takes to reach the required vacuum is related to both pump displacement and the size of the connecting line between the pump and the system.

Information Sheet

Pump Displ.	Conn. Line (6′)	Final Absolute Pressure	
		Low Vacuum	High Vacuum
1 CFM	¼″ I.D.	57 min.	78 min.
2 CFM	¼″ I.D.	39 min.	56 min.
5 CFM	¼″ I.D.	28 min.	43 min.
1 CFM	⅜″ I.D.	40 min.	51 min.
2 CFM	⅜″ I.D.	22 min.	29 min.
5 CFM	⅜″ I.D.	12 min.	16 min.
1 CFM	½″ I.D.	37 min.	45 min.
2 CFM	½″ I.D.	19 min.	23 min.
5 CFM	½″ I.D.	8 min.	10 min.

11. **Use and care of vacuum measuring equipment**

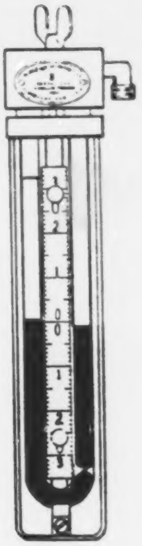
   a. The most commonly used piece of equipment for measuring a vacuum is the compound gauge on a technician's manifold gauge set.

   b. The compound gauge can accurately measure a vacuum to 28″ or 29″ hg, but there are service situations where the compound gauge should not be used as the sole indicator of the level of vacuum.

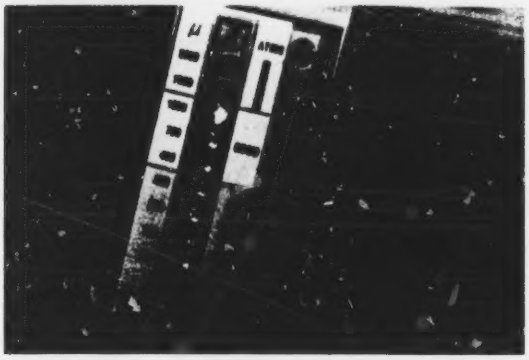
   c. Because of its affordability, a mercury manometer is still used by many ACR technicians for vacuum measurements, and it can accurately record vacuum levels to 29.8″ hg.

Information Sheet

d. Be sure to cap a mercury manometer when it is not in use, and use and store it in a vertical position.



e. Vacuums below 29.8" hg should be measured in microns, and this is accomplished with a micron gauge.



f. Micron gauges are either of a thermocouple type or electronic, but in either case, they are expensive and should be handled with care.

12. Reading a mercury manometer

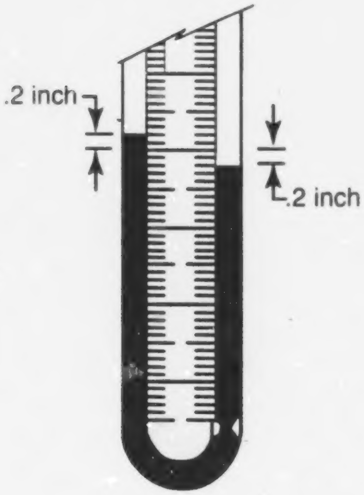
a. Since vacuum readings on a mercury manometer are actually negative pressure readings, the mercury moves from the left leg of the manometer to the right leg of the manometer to give a reading in "hg".

Note: If you were measuring psi, the movement would be from right to left.

Information Sheet

b. To read a mercury manometer, add the amount below zero on the right leg to the amount above zero on the left leg, and then subtract that from 29.92″ hg.

Example: The manometer in the following graphic reads .2″ below zero on the right leg and .2″ above zero on the left leg; add the two together to get .4″ hg, and then subtract that from 29.92″ hg; the vacuum reading is 29.52″ hg which is close to the limit of the vacuum level that a manometer can accurately measure.



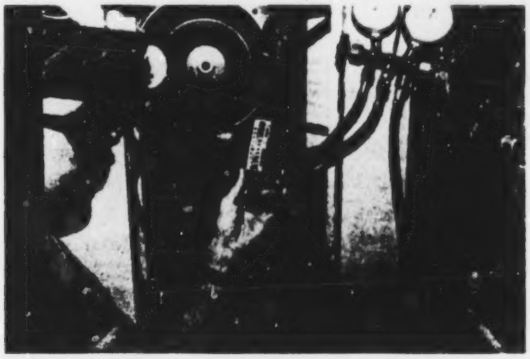
13. Using/reading a micron gauge

a. A micron gauge is an electronic instrument used to measure vacuum, and is popular because it is small and can be hooked up directly to the system or to a vacuum pump.

b. Some micron gauges are hand-held and require no auxiliary power because they have an on-board battery.

Information Sheet

c. To read a micron gauge, hook it up, turn it on, and check the color-coded LED display for the vacuum level; it will record effectively form 5,000 microns to 50 microns.



d. Keep the micron gauge in its cover in a secure spot in your tool kit when it is not in use because it is an expensive instrument.

14. Guidelines for evacuation

a. Evacuation of a system should not begin until the integrity of the system has been verified; verifying system integrity means leaks have been repaired, the system has been pressurized and leak tested, and the pressurizing gas has been removed.

b. Attach a manifold gauge set to the system with the center hose attached to the evacuation equipment.

c. Measure the temperature of the system, and use a vacuum table to determine the vacuum required to vaporize the moisture in the system.

d. Measure system vacuum with a mercury manometer or a micron gauge.

e. If a manifold gauge set is attached to both the high and low sides of the system and you want a verifying vacuum measurement from a micron gauge or a manometer, use a tee off one of the service ports to make the hook up.

f. Begin evacuation through the high side of the system until you reach 5″ hg, and then evacuate through the low side.

g. If the evacuation equipment will not permit a deep evacuation to at least 500 microns, you should double or triple evacuate the system, and the system may also require warming.

Information Sheet

h. If you reach a level of 500 microns, continue to evacuate for at least 20 minutes more to assure that the system is completely degassed and dehydrated.

i. In all cases, the vacuum level must be low enough to vaporize moisture at the temperature of the coolest part of the system.

j. To assure that moisture levels are reduced to acceptable levels, use double or triple evacuation and insert dry nitrogen after each evacuation.

k. After reaching a final vacuum it is good procedure to allow the system to stand for at least 15 minutes to verify that there are no leaks or moisture present.

l. If the vacuum level changes more than a few hundred microns, the system probably still contains moisture or a leak is allowing air to enter the system; the evacuation procedure has to be repeated.

m. If the vacuum holds for at least 15 minutes, the system is ready for charging.

15. Characteristics of charging equipment

a. Charging cylinders measure weight by volume, and it is important to select a charging cylinder calibrated for the type of refrigerant used.

b. Charging cylinders come in various sizes, and it is important to select a size that will permit you to read the smallest increments of weight; in other words, select a cylinder that will measure pounds and ounces or ounces and increments of ounces.

c. Some charging cylinders are equipped with built-in heaters that will raise the pressure of the refrigerant charge in order to vaporize the refrigerant for faster charging.

d. A charging cylinder should be calibrated for the specific refrigerant being used and for the pressure it will be under, and then the cylinder can be filled to an exact amount of monitoring the level in the clear tube that runs up the side of the cylinder.

e. Vapor charge from the valve int he top of the charging cylinder and liquid charge from the valve in the bottom of the cylinder.

f. Scales selected to weigh refrigerant must be approved by the Bureau of Weights and Measures if the scales are used to determine the cost to a customer; bathroom scales are not accurate enough.

g. Electronic scales are accurate and will measure to 1/10th of a pound.

h. Charging a system with an accurate amount of refrigerant is vital to maximum performance and all equipment used for the procedure should be quality instruments which are kept clean and properly stored.

Information Sheet

16. Using weight or volume to charge a system

a. If you can determine the exact weight of the refrigerant required, the most accurate method for charging a system is by weight.

b. The weight of the required refrigerant charge should be available on the system data plate or in the manufacturer's installation instructions.

c. For small appliances or package-type systems that hold 5 pounds of refrigerant or less, the most accurate method of charging is by volume using a charging cylinder.

d. The volume charging method with a charging cylinder can also be used for small split systems if you can determine the exact amount of refrigerant required.

e. When a charging cylinder is not available, a refrigerant charge should be weighed on a good set of mechanical or digital scales; in fact, some digital scales measure within a tenth of a pound.

f. Whether charging by weight or by volume, keep records for customer billing and EPA requirements, and tag the equipment with service information that service technicians can reference in the future.

17. Using a sight glass for charging

a. When the amount of refrigerant required to charge a system is simply not available, you may be able to charge the system by monitoring the sight glass or liquid indicator.

b. Most systems that have a thermostatic expansion valve for a metering device will contain a sight glass or liquid indicator which shows the condition of refrigerant reaching the metering device.

CAUTION! WET

Information Sheet

c. When only liquid is reaching the metering device, the system is operating at maximum efficiency, but when the liquid indicator shows bubbles, it means that the system is low on refrigerant.

Note: All other conditions such as air or water flow at the evaporator or condenser must be normal.

d. Charging by using a sight glass means to charge the system until the bubbles in the sight glass become liquid; this method of charging is not as accurate as weight or volume, but it results in close to maximum efficiency performance.

18. Charging with a superheat charging chart

a. When manufacturer's charging guidelines are not available for a system containing a fixed metering device such as an orifice or a capillary tube, charging can be accomplished by referencing a standard superheat charging chart.

Suction Line Temperature/Pressure Parameters

OUTDOOR AMBIENT (°F)	SUCTION PRESSURE AT OUTDOOR SECTION (PSIG)																								
	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
	SUCTION LINE TEMPERATURE (± 3°F.)																								
65	37	42	47	53	59	64	69	71	75	79	82	85													
70	32	37	43	48	53	59	64	69	71	75	79	82	85												
75		33	38	43	49	54	59	65	69	72	76	79	83	85											
80			32	38	43	48	54	59	64	69	72	75	79	81	85										
85				32	38	41	48	53	58	64	69	71	75	78	81	84									
90						35	40	47	52	57	62	65	68	72	75	78	81	85							
95								40	44	49	54	59	62	66	70	73	76	79	82	85					
100										44	48	53	58	63	65	69	72	75	78	81	85				
105											42	47	50	55	60	66	69	71	75	78	80	83	86		
110													45	50	55	60	65	68	70	73	76	79	82		
115															51	55	60	63	66	69	72	75	78	81	84

b. To use the chart effectively, first measure the ambient temperature of the condensing unit, and then measure suction line temperature and pressure.

Note: All other conditions such as air or water flow at the evaporator and condenser must be normal.

c. Compare your readings with the readings on the p/t chart and adjust the system charge until system readings agree with chart readings.

d. Charging a system with superheat references may not meet manufacturer's recommendations, but the process produces efficient results, and a system can even be fine tuned with additional monitoring.

Information Sheet

19. Special considerations for liquid and vapor charging

a. Adding refrigerant to a system which already contains some refrigerant is almost always accomplished with a vapor charge fed into the low pressure side of the system while the system is running.

b. Take care to never add liquid refrigerant to the low side of a system; the liquid can severely damage or ruin the compressor.

c. Refrigerant can be added to the system in liquid form through the liquid line by using a charging cylinder.

d. Without a charging cylinder, liquid charging is very time consuming, and if attempted at all, should be done with extreme caution.

20. Keeping charging records

a. Keep track of the amount of refrigerant used to charge a system so the customer can be sent an accurate bill; good records also assure compliance with EPA regulations that require a business to keep track of refrigerant it uses.

b. The service date, type of refrigerant, and amount of the charge placed in the system should be recorded on a tag and left on or near the system to assure that the next service technician will have accurate information to work with.

Note: The service tag is a good business tool because customers will see the company name and phone number and probably call the company again for any kind of AC, refrigeration, or heating problem.

c. Other technical information that needs to be recorded and kept on file includes:

(1) Air/water temperatures in and out of the evaporator.

(2) Air/water temperatures in and out of the condenser.

(3) Suction and liquid line pressures, if access is available.

(4) Suction line temperature if it is part of operating parameters.

d. Good records help a company build a life history of a system so that service can be accomplished faster, better, and at less expense to the customer; it is that part of the ACR business that builds image and prestige.

Information Sheet

21. Procedures for preparing a small refrigeration system for operation

> These procedures are typical for preparing a small appliance or small refrigeration system for operation; conditions may require other assembly or parts repair or replacement.

a. Install a line tap access valve (Job Sheet 1).

b. Install a filter-drier on a capillary tube (Job Sheet 2).

c. Pressurize a system with R-22 and dry nitrogen (Job Sheet 3)

d. Use a halide torch to check for leaks (Job Sheet 4).

e. Evacuate a system and verify level with a micron vacuum gauge (Job Sheet 5).

f. Fill a charging cylinder (Job Sheet 6).

g. Vapor charge a system from a charging cylinder (Job Sheet 7).

h. Make appropriate entries on a service work order.

Note: For the convenience of evaluation, the service work order for these procedures is presented as an activity in Assignment Sheet 1.

22. Procedures for preparing a refrigeration system for operation with a thermostatic expansion valve

> These procedures are typical for preparing a refrigeration system that uses a thermostatic expansion valve; conditions may require other assembly or parts repair or replacement.

a. Install a thermostatic expansion valve with flare fittings (Job Sheet 8).

b. Install a sight glass with flare fittings (Job Sheet 9).

c. Install a filter-drier with flare fittings (Job Sheet 10).

d. Pressurize a system with dry nitrogen and leak test (Job Sheet 11).

e. Triple evacuate a refrigeration system (Job Sheet 12).

f. Liquid charge a refrigeration system from a refrigerant cylinder (Job Sheet 13).

Information Sheet

g. Check and adjust a thermostatic expansion valve using superheat parameters (Job Sheet 14).

h. Make appropriate entries on a service work order.

Note: For the convenience of evaluation, the service work order for these procedures is presented as an activity in Assignment Sheet 2.

23. **Procedures for preparing an air conditioning system for operation with a fixed metering device**

> These procedures are typical for preparing an air conditioning system that uses a fixed metering device such as a capillary tube, a fixed orifice, or a piston-type orifice; conditions may require other assembly or parts repair or replacement.

a. Install a core-type access valve (Job sheet 15).

b. Install a filter-drier with sweat fittings (Job Sheet 16).

c. Pressurize a system with R-22 and dry nitrogen (Job Sheet 17).

d. Leak test a refrigeration system with an electronic leak detector (Job Sheet 3).

e. Evacuate a system and verify vacuum level with a mercury manometer (Job Sheet 18).

f. Liquid charge using a charging cylinder (Job Sheet 19).

g. Vapor charge a refrigeration system from a refrigerant cylinder (Job Sheet 20).

h. Use suction line pressure/temperature parameters to evaluate a system charge (Job Sheet 21).

i. Make appropriate entries on a service work order.

Note: For the convenience of evaluation, the service work order for these procedures is presented as an activity in Assignment Sheet 3.

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Assignment Sheet 1—Complete Service work Order 1

> **Evaluation criteria:** Evaluate according to specified job sheets related to the procedures for preparing a refrigeration system for operation.

Customer's Name ______________________

Customer's Address ______________________

Brief description of problem ______________________

____

Time and date service or repair started _____ __________ Ended _____ __________

Evaporator air or water temperatures in ________ out ________

Condenser air or water temperatures in ________ out ________

Suction pressure ________ Liquid pressure ________ Suction line temperature ________

Materials used to complete service or repair (continue list on back of form if needed)

____

____

Was refrigerant removed? If yes, indicate disposition. ☐ Yes ☐ No
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight ______________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? ______________
What amount of refrigerant was added? ______________
Was a dated service tag left on system to indicate refrigerant and amount? ☐ Yes ☐ No

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ______________________ Date __________

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Assignment Sheet 2—Complete Service Work Order 2

Evaluation criteria: Evaluate according to specified job sheets related to the procedures for preparing a refrigeration system for operation.

Customer's Name ______________________________

Customer's Address ______________________________

Brief description of problem ______________________________

____

Time and date service or repair started ______________ Ended ______________

Evaporator air or water temperatures in ________ out ________

Condenser air or water temperatures in ________ out ________

Suction pressure ________ Liquid pressure ________ Suction line temperature ________

Materials used to complete service or repair (continue list on back of form if needed)

____

____

Was refrigerant removed? If yes, indicate disposition. ☐ Yes ☐ No
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight ______________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? ______________
What amount of refrigerant was added? ______________
Was a dated service tag left on system to indicate refrigerant and amount? ☐ Yes ☐ No

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ______________________ Date ____________

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Assignment Sheet 3—Complete Service Work Order 3

Evaluation criteria: Evaluate according to specified job sheets related to the procedures for preparing a refrigeration system for operation.

Customer's Name ______________________________

Customer's Address ______________________________

Brief description of problem ______________________________

____

Time and date service or repair started __________ Ended __________

Evaporator air or water temperatures in ______ out ______

Condenser air or water temperatures in ______ out ______

Suction pressure ______ Liquid pressure ______ Suction line temperature ______

Materials used to complete service or repair (continue list on back of form if needed)

____

____

Was refrigerant removed? If yes, indicate disposition. ☐ Yes ☐ No
☐ Recovered on site and returned in total to the system at end of service.
☐ Recycled on site and returned in total to the system at end of service.
☐ Retained in approved recovery cylinder for future disposition.
If refrigerant was recovered and retained, include type and weight __________

Was refrigerant added to the system as a part of service? ☐ Yes ☐ No
If refrigerant was added, what refrigerant was used? __________
What amount of refrigerant was added? __________
Was a dated service tag left on system to indicate refrigerant and amount? ☐ Yes ☐ No

Did any amount of refrigerant have to be vented to the atmosphere in order to facilitate reasonable service activity? ☐ Yes ☐ No

Were "de minimus" venting guidelines observed during service? ☐ Yes ☐ No
Note: If your answer to the above question is No, explain the circumstances on the back of this form.

Signature of Service Technician ______________________ Date __________

Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 1—Install a Line Tap Access Valve

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Line tap properly installed and pierced	_____
Manifold gauge set properly installed and used	_____
Pinch-off tool used to seal line for valve removal	_____
Leak check conducted	_____

A. Tools and materials

Refrigeration system selected by instructor
Line tap valve
Torch and striker
Hard solder and sand cloth
Open end wrench, Phillips screwdriver, and pinch-off tool
Hex-key wrench
Dry shop towel and damp shop towel
Safety glasses and colored safety glasses

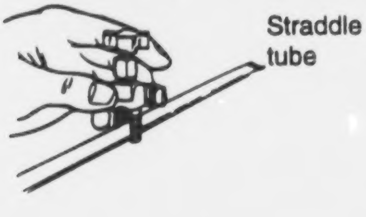
B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is a part of this activity.

☐ 2. Put on safety glasses.

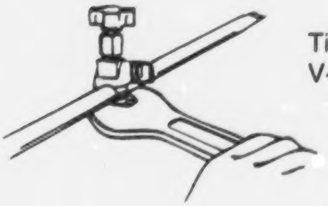
☐ 3. Clean an area on the pressure stub for the line tap valve to be installed.

☐ 4. Place the line tap in place so that it straddles the tubing.



Job Sheet 1

☐ 5. Tighten the line tap onto the tubing with an open-end wrench or hex-key wrenches.



☐ 6. Tighten a hose from your manifold gauge set onto the valve port.

☐ 7. Check to make sure the manifold gauge valves are closed.

☐ 8. Pierce the tubing by turning the tap set handle, or, if required, use a hex-key wrench.

☐ 9. Purge the hose at the manifold gauge connection.

Note: Steps 10 through 13 are required only if you are using a line tap valve that has to be brazed on. Ask your instructor about using this option.

☐ 10. Place the line tap valve onto the selected spot in the tubing, braze it in place, and then leak test the valve.

☐ 11. Place an "O" ring over the tap and insert the tap into the valve.

☐ 12. Tighten the cap down on the valve so that the tap will puncture the tubing and crimp the end of the valve that holds the core in place.

☐ 13. Connect gauges from the manifold gauge set as with any core-type access valve.

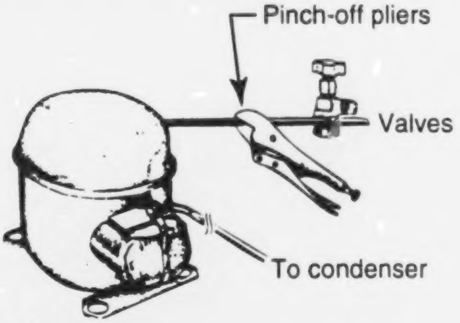
Note: The following procedures follow Step 9 if you are not using a braze-on line tap. The system at this point can be accessed for service or parts replacement after refrigerant has been removed.

☐ 14. Remove refrigerant if the system has to be repaired or parts replaced.

☐ 15. Complete service as required and then remove the hoses from the line tap.

Job Sheet 1

☐ 16. If you used a clamp-on type line tap, place a pinch-off tool on the pressure stub or tubing, pinch the line off.



☐ 17. Remove the valve.

> **Caution: Be sure the stub is completely sealed before removing the valve.**

☐ 18. Put on colored safety glasses.

☐ 19. Light and adjust the torch.

☐ 20. Braze the opening where the valve pierced the stub or the tubing.

☐ 21. Turn the torch off.

☐ 22. Cool the pressure stub or tubing with a damp shop cloth.

☐ 23. Remove the pinch-off tool.

☐ 24. Check for leaks.

☐ 25. Have your instructor check your work.

☐ 26. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 2—Install a Filter-Drier on a Capillary Tube

Name ______________________________. Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Capillary tube and line properly prepared	______
Filter-drier properly installed on cap tube side	______
Brazing alloy applied effectively	______
Filter-drier properly joined to liquid line	______

A. Tools and materials

Domestic or other small refrigeration system selected by instructor
Filter-drier for selected system
Torch and striker
Hard solder and sand cloth
Tubing cutter, tapered three-cornered file, orifice file, pliers
Manifold gauge set
Clean, damp shop towel
Safety glasses and colored safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work order in Assignment Sheet 1; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. If the refrigeration system is under pressure, remove pressure as illustrated in previous job sheets.

☐ 4. Cut the liquid line close to the inlet of the metering device.

☐ 5. Put on colored safety glasses.

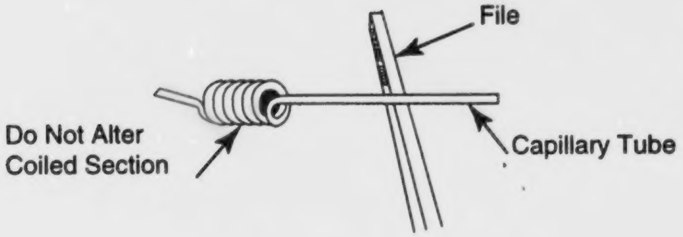
☐ 6. Light your torch and heat the capillary tube and the tubing into which it is inserted until the two can be pulled free of each other.

Job Sheet 2

☐ 7. Shut the torch off, put on your regular safety glasses.

☐ 8. If the capillary tube cannot be removed with the torch, score the cap tube line with a file and break it off squarely so that you remove the least amount of capillary tube as possible.

Caution: Do not cut a capillary tube with a tubing cutter because it will reduce the inside diameter and diminish its operating volume.

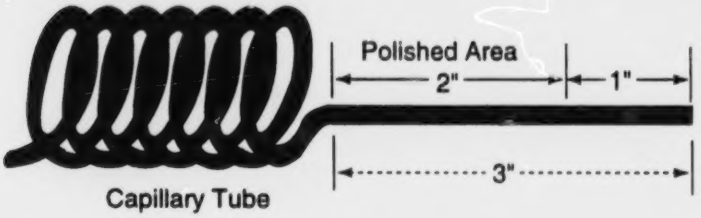


☐ 9. Straighten the end of the capillary tube; three inches will be sufficient.

☐ 10. Ream the end of the capillary tube with care.

☐ 11. Measure an inch from the end of the cap tube and then polish a two-inch section beyond that point.

Note: Leaving one inch of the cap tube uncleaned will help keep the solder from flowing down the tube and restricting the end.



☐ 12. Prepare the liquid line to receive the other end of the drier.

Note: You may have to swage the joint for a good connection.

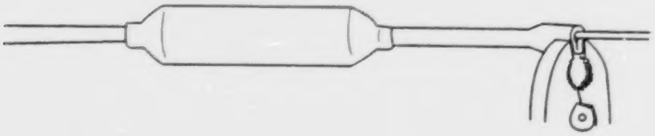
Job Sheet 2

☐ 13. If you are using a filter-drier with an access core-type valve, remove the core to prevent the heat from damaging it.

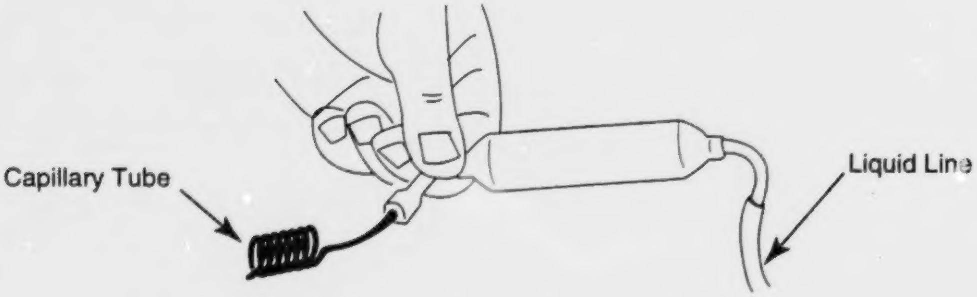
☐ 14. Insert approximately 1½" of capillary tube into the outlet end of the filter-drier, and be careful not to kink the capillary tube.

☐ 15. Crimp the tubing, if necessary.

Note: It may be better to place a solid piece of copper wire or a small drill bit into the end of the drier while crimping to prevent damage to the capillary tube.



☐ 16. Tilt the outlet end of the filter-drier down to help prevent the solder from going down the capillary tube and causing a restriction.



☐ 17. Put on colored safety glasses and light the torch again.

☐ 18. Apply heat to the joint away from the drier.

☐ 19. Apply brazing alloy.

☐ 20. Remove heat as soon as solder flows around the joint.

☐ 21. Attach the other end of the drier to the liquid line and braze it into place.

☐ 22. Turn the torch off.

Job Sheet 2

☐ 23. Have your instructor check your work.

☐ 24. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 3—Pressurize a Refrigeration System With Refrigerant and Dry Nitrogen

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
System charge placed into system	______
Dry nitrogen placed into system	______
System pressurized to 100 psig	______
System leak checked with proper equipment	______

A. Tools and materials

Refrigeration system selected by instructor
Cylinder with refrigerant matching system refrigerant
Cylinder of dry nitrogen
Manifold gauge set
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Connect the manifold gauge set to the system, if not already done.

☐ 4. Crack the service valves, if required.

☐ 5. Attach the center hose of the manifold gauge set to the refrigerant cylinder.

☐ 6. Leave refrigerant cylinder in the upright position.

☐ 7. Open the refrigerant cylinder valve.

☐ 8. Open the valve on the high side of the manifold gauge set.

Job Sheet 3

☐ 9. Allow refrigerant to enter the system until you have a pressure reading of 5 psig.

☐ 10. Close the high side manifold valve.

☐ 11. Close the refrigerant cylinder valve.

☐ 12. Loosen the refrigerant hose at the cylinder valve.

☐ 13. Allow hose pressure to escape.

Note: This is permissible "de minimus" venting.

☐ 14. Remove the hose from the refrigerant cylinder.

☐ 15. Attach the manifold gauge set center hose to the nitrogen cylinder.

☐ 16. Check to be sure the regulator adjusting screw is not turned in.

☐ 17. Crack the nitrogen cylinder one-quarter of a turn.

☐ 18. Purge the center hose.

☐ 19. Turn the regulator and adjusting screw clockwise until you get a pressure reading of 100 psig, which generally is sufficient for leak testing.

☐ 20. Open the valve on the high side of the manifold gauge set.

☐ 21. Allow high side and low side pressures to equalize.

☐ 22. Leak check the system with a halide torch or an electronic leak detector.

☐ 23. Check with your instructor if you find a leak.

☐ 24. Have your instructor check your work.

☐ 25. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 4—Leak Check With a Halide Torch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Colored safety glasses used	______
Striker used to ignite flame	______
Flame extinguished with proper procedure	______

A. Tools and materials

Halide leak detector torch as selected by instructor
Propane or other fuel gas as selected by instructor
Friction-type striker
Colored safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is part of this activity.

☐ 2. Put on colored safety glasses.

☐ 3. Install the halide leak detector unit onto the fuel gas cylinder.

☐ 4. Open the torch handle valve about a quarter of a turn.

Job Sheet 4

☐ 5. Hold the striker above the halide leak detector unit and place your other thumb over the sniffer hose as you start to light the torch.

BERNZOMATIC
PROPANE

☐ 6. Strike the striker immediately and light the torch.

☐ 7. Remove your thumb from the sniffer bulb.

☐ 8. Adjust the flame so that the inner blue cone just barely touches the reactor plate.

☐ 9. Allow your instructor to check your flame.

☐ 10. Use the "sniffer" hose to check for leaks while being careful to keep the torch flame pointed safely away from the system.

☐ 11. Watch for changes in flame color to indicate the presence of refrigerant, and remember to hold the sniffer hose below suspected leak areas because refrigerant is heavier than air.

☐ 12. Turn the tank valve off to shut off the fuel supply, and let the flame burn itself out.

☐ 13. Close the torch handle valve.

☐ 14. Have your instructor evaluate your activity.

☐ 15. Permit the leak detector unit to cool and then remove it from the fuel cylinder.

☐ 16. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 5—Evacuate a Refrigeration System and Verify Level With a Micron Vacuum Gauge

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set and vacuum pump properly set up	______
Micron vacuum gauge properly attached to system	______
"No Venting" regulation effectively applied	______
Evacuation complete to 500 microns	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set, vacuum pump, and micron vacuum gauge
Open end wrench and refrigeration ratchet
Safety glasses
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is part of this activity.

☐ 2. Attach the manifold gauge set to the system, if not already done.

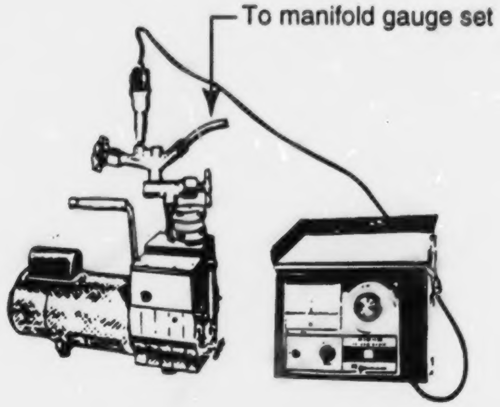
☐ 3. Crack the system service valves, if necessary.

☐ 4. Purge any leak detecting pressure that may exist.

Caution: "De minimus" venting regulations apply to this activity!

Job Sheet 5

☐ 5. Connect the electronic vacuum gauge to the system, using a tee or a second manifold gauge set.



☐ 6. Connect the manifold gauge set center hose to the inlet port of the vacuum pump.

☐ 7. Remove the cap from the vacuum pump outlet port, and make sure the ballast is open.

☐ 8. Start the vacuum pump.

☐ 9. Open the high side valve on the manifold gauge set.

☐ 10. Watch for the compound gauge to indicate 5″ Hg or more, and then open the low side valve on the manifold gauge set.

☐ 11. Watch for the compound gauge to indicate 29″ Hg, and then start reading the electronic vacuum gauge so your evacuation will be accurate.

Note: Leave the gas ballast open until evacuation reaches 25″ hg.

☐ 12. Evacuate to 500 microns.

☐ 13. Continue to evacuate for 20 minutes after reaching 500 microns to be sure that all moisture has been removed from the system.

☐ 14. Have your instructor evaluate your process and your final micron reading.

☐ 15. Open the gas ballast and turn the vacuum pump off.

Job Sheet 5

☐ 16. Allow the system to sit for 15 minutes and check to see if the reading has dropped more than a few hundred microns which wold indicate that:

   (a) The system still contains moisture; or

   (b) There is a leak allowing air into the system.

☐ 17. Have your instructor check your work.

☐ 18. Check with your instructor about continuing with another activity, or clean the area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 6—Fill a Charging Cylinder

Name ________________________________ Attempt Number ________

Date ________________________________ Overall Rating ________

Evaluation criteria	**Rating**
Charging cylinder set for proper refrigerant	______
Charging cylinder filled to proper amount	______
"No Venting" regulation effectively applied	______

A. Tools and materials

Charging cylinder
Refrigerant cylinder as selected by instructor
Charging hoses
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is part of this activity.

☐ 2. Check the refrigerant cylinder and note the type of refrigerant you will be using.

☐ 3. Set the scale on the charging cylinder for the correct refrigerant.

☐ 4. Put on safety glasses.

☐ 5. Connect the charging hose to the bottom valve on the charging cylinder.

☐ 6. Connect the other end of the charging hose to the valve on the refrigerant cylinder.

Note: If the refrigerant cylinder is a dual-valve type, be sure to connect the charging hose to the vapor valve.

☐ 7. Open the refrigerant cylinder valve.

Job Sheet 6

☐ 8. Open the bottom valve on the charging cylinder.

☐ 9. Adjust the scale on the charging cylinder so that it corresponds with the reading on the cylinder pressure gauge.

☐ 10. Invert the refrigerant cylinder and place it so that it is physically higher than the charging cylinder.

☐ 11. Open the top valve on the charging cylinder to permit air to bleed from the cylinder.

☐ 12. Close the top valve on the charging cylinder when liquid refrigerant becomes visible in the cylinder tube.

☐ 13. Double check to make sure the charging cylinder is set for the right refrigerant.

☐ 14. Fill the charging cylinder to the required amount.

☐ 15. Close the charging cylinder bottom valve.

☐ 16. Place the charging cylinder higher than the upright refrigerant cylinder to allow liquid to flow from the hoses back into the refrigerant cylinder.

☐ 17. Close the refrigerant cylinder valve.

☐ 18. Loosen the charging hose so refrigerant will be purged from it.

☐ 19. Remove the charging hose.

☐ 20. Have your instructor check the charging cylinder for proper filling.

☐ 21. Take the charging cylinder to the unit to be charged.

☐ 22. Check with your instructor about continuing another activity, or clean the area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 7—Vapor Charge a Refrigeration System From a Charging Cylinder

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Manifold gauge set and charging cylinder properly set up	______
System started at proper time to stabilize pressures	______
P/T chart properly used to determine pressures	______
System service valves back seated after charging	______
Service form properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set and charging cylinder with correct refrigerant charge
Open end wrench and refrigeration ratchet
Appropriate P/T chart for reference
Safety glasses and shop towel
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 1; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Using the manifold gauge set already in place on the system under vacuum, attach the manifold gauge set center hose to the top valve on the charging cylinder.

☐ 4. Open the valve on the top of the charging cylinder.

☐ 5. Purge center hose at the manifold.

☐ 6. If the charging cylinder has a heater, energize it and allow it to heat the cylinder until the pressure reaches approximately 150 psig.

Job Sheet 7

☐ 7. Open the high side valve on the manifold gauge set.

☐ 8. Allow vapor to enter the system until no liquid is visible in the charging cylinder.

☐ 9. Close the high side valve on the manifold gauge set.

☐ 10. If liquid is still visible after a few minutes, start the system.

Note: If the system is equipped with a low pressure safety switch, it may have to be jumped during the charging process, but check with your instructor before attempting the procedure.

☐ 11. Crack the low side valve on the manifold gauge set to allow refrigerant to enter the system.

☐ 12. Allow the gauge pressure reading to increase 20 to 30 psig above system pressure.

☐ 13. Close the low side valve on the manifold gauge to stop charging about 15 seconds after liquid is no longer visible in the charging cylinder and turn off the heater.

☐ 14. Allow system to continue running for pressures to stabilize.

☐ 15. Recheck operating pressures, and include them on your Service Work Order in Assignment Sheet 1; for now, you may want to note them on the back of this sheet.

☐ 16. Have your instructor check your procedure.

☐ 17. Back seat the system service valves, if required.

☐ 18. Close the valve on the charging cylinder.

☐ 19. Purge the hoses on the manifold gauge set.

☐ 20. Remove manifold gauge and replace and tighten all valve caps.

☐ 21. Check with your instructor about continuing with another activity, or clean the area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 8—Install a Thermostatic Expansion Valve With Flare Fittings

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
System properly prepared for installation	______
Flare connections prepared and properly installed	______
Sensing bulb properly installed	______
TXV properly installed	______

A. Tools and materials

Refrigeration system w/expansion valve w/male fittings
Manifold gauge set
Tubing cutter, flaring tool, flaring block
Flare fittings
Flare-nut wrenches, open end wrenches, refrigeration ratchet
Oil can
Screwdriver
Thermostatic expansion valve with male flare fittings
Shop towel
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 2; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Install manifold gauge set, if not already installed on system.

☐ 4. If system is under pressure, properly remove refrigerant.

☐ 5. Use a screwdriver and an open end wrench to remove the sensing bulb from the suction line, and be sure to note the sensing bulb position on the line.

Job Sheet 8

☐ 6. Use a flare nut wrench and an open end wrench to remove the TXV from the liquid line.

☐ 7. Use a flare nut wrench and an open end wrench to disconnect the TXV from the distributor.

☐ 8. Use a flare nut wrench and an open end wrench to disconnect the external equalizer line from the TXV.

Note: Some TXVs will not have an eternal equalizer.

☐ 9. Remove the TXV.

☐ 10. Remove the protective caps from the new TXV and place them on the fittings of the TXV you removed.

☐ 11. Place the new TXV into position where the old TXV was removed.

☐ 12. Tighten the flare nuts finger tight.

☐ 13. Oil the fittings with refrigeration oil.

☐ 14. Use a flare-nut wrench and an open end wrench to tighten the flare nuts.

☐ 15. Clean the suction line thoroughly where the sensing bulb was removed.

☐ 16. Fasten the new sensing bulb to the suction line with new copper clamps.

☐ 17. Have your instructor check your work.

☐ 18. Check with your instructor about continuing with another activity, or clean up the area and secure tools and equipment.

Evaluator's comments: ____________________

____

____

Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 9—Install a Liquid Indicator With Flare Fittings

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
System properly prepared for installation	______
Flare connections prepared and properly installed	______
Liquid indicator properly installed	______

A. Tools and materials

Refrigeration system with expansion valve as selected by instructor
Manifold gauge set
Tubing cutter, flaring tool, flaring block
Flare fittings
Flare-nut wrench, open end wrench
Oil can
Liquid indicator
Shop towel
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 2; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Install manifold gauge set, if not already installed on system.

☐ 4. If system is under pressure, slowly release nitrogen pressure, recover refrigerant, or pump down.

☐ 5. Cut the liquid line between the location of the filter-drier and the inlet of the metering device, at a point approved by your instructor.

☐ 6. Place the flare nuts on the tubing.

Job Sheet 9

☐ 7. Flare the tubing.

☐ 8. Oil the fittings lightly.

☐ 9. Install the liquid indicator.

☐ 10. Tighten both flare nuts finger tight.

☐ 11. Hold the body of the liquid indicator with an open end wrench while you tighten the flare nuts with a flare-nut wrench.

☐ 12. Have your instructor check your work.

☐ 13. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet [illegible] —Install a Filter-Drier With Flare Fittings

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
System properly prepared for installation	______
Flare connections prepared and properly installed	______
Liquid indicator properly installed	______

A. Tools and materials

Refrigeration system with expansion valve as selected by instructor
manifold gauge set
Tubing cutter, flaring tool, flaring block
Flare fittings
Flare-nut wrench, open end wrench, refrigeration ratchet
Oil can
Filter-drier with male flare fittings and two flare nuts
Shop towel
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment 2; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Install manifold gauge set, if not already installed on system.

☐ 4. If system is under pressure, slowly release nitrogen pressure, recover refrigerant or pump down.

☐ 5. Cut the liquid line at a location approved by your instructor.

☐ 6. Place the flare nuts on the tubing.

Job Sheet 10.

☐ 7. Flare the tubing.

☐ 8. Remove the protective cap from one end of the filter-drier.

Note: Remove only one cap at a time, but wait until you are ready to install the filter-drier because the desiccant will become saturated with moisture if you leave the cap off the filter-drier.

☐ 9. If you are using a directional filter-drier, be sure to install it with the refrigerant flow toward the metering device.

Note: An arrow on the filter will indicate flow direction, or the words IN and OUT will be used.

☐ 10. Tighten the flare nut finger tight.

☐ 11. Remove the protective cap from the other end of the filter-drier.

☐ 12. Oil the fittings with refrigeration oil.

☐ 13. Tighten the flare nut finger tight.

☐ 14. Place the flare-nut wrench on the flare nut as you place the open end wrench on the hexagon part of the filter-drier male flare fitting, and tighten both flare nuts.

☐ 15. Have your instructor check your work, and conduct a leak check if your instructor requests it.

☐ 16. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 11—Pressurize a Refrigeration System With Dry Nitrogen and Leak Test

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set properly attached	______
Dry nitrogen and regulator properly used	______
Leak testing pressure of 100 psig obtained	______
Leak testing solution properly applied and evaluated	______
Service form properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set; dry nitrogen cylinder with regulator
Open end wrench and refrigeration ratchet
Leak testing solution, soft acid brush, and clean shop cloth
Safety glasses
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 2; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Connect the manifold gauge set to the refrigeration system, if it is not already connected.

☐ 4. Crack the service valves on the refrigeration system, if necessary.

☐ 5. Attach the center hose on the manifold gauge set to the nitrogen regulator.

Job Sheet 11

☐ 6. Turn the nitrogen regulator adjusting screw counterclockwise about three full turns.

☐ 7. Crack the valve on the nitrogen cylinder one-quarter turn.

☐ 8. Turn the regulator adjusting screw clockwise until the gauge shows a pressure of 100 psig because this is a minimum pressure usually required for leak testing.

☐ 9. Open the high side valve on the manifold gauge set.

☐ 10. Allow high side and low side pressures to equalize, and if you do not get positive pressure on the entire system, talk with your instructor before continuing this activity.

☐ 11. Leak test the system by using a soft acid brush to apply bubble solution to connections that are suspected of leaking.

Note: The bubble solution has to be used with a nitrogen charge because halide and electronic detectors will not react to nitrogen.

☐ 12. Note the location of any leak(s) on your service work order, or make a note that there are no leaks.

☐ 13. Have your instructor check your leak testing procedure and results.

Note: If you do find a leak, ask your instructor what procedure to follow, and if you do not find a leak, continue with this activity.

☐ 14. Remove the bubble solution with a clean shop cloth so the solution will not contribute to any corrosion or contamination.

☐ 15. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 12—Triple Evacuate a Refrigeration System

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set and vacuum pump properly set up	______
Mercury manometer properly attached to system	______
"No Venting" regulation effectively applied	______
Triple evacuation completed and verified	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set, vacuum pump, and mercury manometer
Open end wrench and refrigeration ratchet
Safety glasses
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you need to complete the Service Work Order in Assignment sheet 2; it is part of this activity.

☐ 2. Attach the manifold gauge set to the system, if it is not already attached.

☐ 3. Crack the system service valves, if necessary.

☐ 4. Purge any leak testing pressure that may be present in the system.

Caution: "De minimus" venting regulations apply to this activity!

☐ 5. Connect the center hose of the manifold gauge to the vacuum pump inlet port.

☐ 6. Remove the cap from the vacuum pump outlet port.

Job Sheet 12

☐ 7. Start the vacuum pump with ballast open.

☐ 8. Open the high side valve on the manifold gauge set.

☐ 9. Open the low side valve on the manifold gauge set when the compound gauge shows a vacuum of 5″ Hg or more.

☐ 10. Close the ballast when the compound gauge reaches 25″ hg.

☐ 11. Evacuate until the compound gauge shows a vacuum of 29″ hg.

☐ 12. Continue to evacuate for 20 minutes after reaching 29″ Hg.

Note: If system temperature is below 75°F, the system must be warmed up, or you must reach a deeper vacuum and use a proper instrument to measure the deeper vacuum; it cannot be done with a compound gauge.

☐ 13. Close the manifold gauge valves.

☐ 14. Turn the vacuum pump off.

☐ 15. Disconnect the center hose from the vacuum pump.

☐ 16. Connect the center hose to a dry nitrogen or R-22 cylinder.

☐ 17. Purge air from the center hose.

Caution: "De minimus" venting regulations apply to this activity!

☐ 18. Open the high side valve on the manifold gauge set.

☐ 19. Pressurize the system to 5 psig.

☐ 20. Allow system to set for 5 minutes.

☐ 21. Discharge pressure.

Caution: "De minimus" venting regulations apply to this activity!

☐ 22. Repeat steps 7 through 21.

☐ 23. Repeat steps 7 through 15.

Job Sheet 12

☐ 24. Have your instructor check your triple evacuation.

☐ 25. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 13—Liquid Charge a Refrigeration System From a Refrigerant Cylinder

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set and refrigerant cylinder properly set up	______
Weight of refrigerant cylinder recorded properly	______
System started and checked for stabilized pressures	______
Amount of refrigerant used properly determined	______
Service form properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Refrigerant cylinder and scales as selected by instructor
Manifold gauge set and P/T chart for refrigerant
Open end wrench and refrigeration ratchet
Safety glasses and a shop towel
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 2; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Connect the manifold gauge set to the liquid receiver service valves or liquid line service valve, if it is not already connected, and attach the center hose to the refrigerant cylinder, or to the vapor valve if the cylinder has dual valves.

☐ 4. Set the refrigerant cylinder in an upright position on the scales.

Job Sheet 13

☐ 5. Open the cylinder valve and purge the center hose at the manifold.

Note: If you're working with a system that has been evacuated, skip to Step 9.

☐ 6. Open the manifold gauge valves and purge the hoses at the service valve gauge ports, or purse at the manifold before opening the gauge valves, if the system has core-type access valves.

☐ 7. Close the valve son the manifold gauge set.

☐ 8. Crack the service valve son the refrigeration system.

☐ 9. Record the weight of the refrigerant cylinder here ______ and use this same figure on your service work order.

☐ 10. Invert the refrigerant cylinder, and place it higher than the system.

☐ 11. Open the high side of the manifold gauge set.

☐ 12. Allow liquid refrigerant to enter the system.

☐ 13. Watch the refrigerant scales and close the manifold gauge valve when the right amount of refrigerant has entered the system.

☐ 14. Start the system and let it run to stabilize system pressures. Service record.

☐ 15. Check for the following indications that additional refrigerant is required:

   (a) Bubbles in the sight glass.

   (b) Low pressure readings.

   (c) Frost on evaporator line.

☐ 16. If additional refrigerant is required, shut the system down, allow the system to stabilize, and then repeat steps 9 through 15.

☐ 17. Record the "after charging" cylinder weight here ______ and include the information on your service work order.

☐ 18. Figure the amount of refrigerant used and enter it here ______ and on your service work order.

☐ 19. Have your instructor check your work.

Job Sheet 13

☐ 20. Back seat the system service valves and replace caps if they were removed.

☐ 21. Remove manifold gauge set and purge hoses for storage.

☐ 22. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 14—Check and Adjust a Thermostatic Expansion Valve Using Superheat Parameters

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Thermometer properly attached to suction line	______
Manifold gauge set properly installed	______
Temperature readings accurately made	______
TXV adjusted for maximum performance	______

A. Tools and materials

Refrigeration system as selected by instructor
Thermometer with remote sensing bulb
Ambient temperature thermometer
Manifold gauge set and P/T chart for refrigerant
Tape or Velcro strap to secure thermometer remote bulb to suction line
Pipe insulation to wrap around sensing bulb
Pencil
Safety glasses and a shop towel

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 2; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Attach the thermometer sensing bulb securely to the suction line near the point where the TXV is fastened to the suction line.

☐ 4. Attach a manifold gauge set to read pressure at the suction line port of the condensing unit, or at the evaporator outlet if it is accessible.

☐ 5. Start the unit and allow line pressures to stabilize for at least 30 minutes.

Job Sheet 14

☐ 6. Read and record the following:

(a) Suction line pressure: ______

(b) Suction line temperature: ______

☐ 7. Read a temperature/pressure chart to determine the temperature of the refrigerant based on the suction line pressure reading you made.

Pressure/Temperature Chart (Italics = "Hg:Bold = PSIG)

TEMP. F.	R-12	R-22	R-502	R-134A	R-406A BUBBLE	R-406A DEWPOINT
–40	*11.0*	0.5	4.1		*7.0*	*17*
–35	*8.4*	2.6	6.5		*5.8*	*15*
–30	*5.5*	4.9	9.2	*9.9*	*3.2*	*12.8*
–25	*2.3*	7.4	12.1	*6.9*	*1.9*	*10.4*
–20	0.6	10.2	15.3	*3.7*	2.3	*7.6*
–15	2.5	13.2	18.8	0.6	4.4	*4.6*
–10	4.5	16.4	22.6	1.9	6.7	*1.4*
–5	6.8	20.1	26.7	4.0	9.2	1.5
0	9.2	24.0	31.3	6.5	11.9	3.5
5	11.8	28.2	35.9	9.1	14.9	5.8
10	14.6	32.8	41.0	11.9	18.1	8.2
15	17.7	37.7	46.5	15.0	21.5	10.8
20	21.0	43.0	52.4	18.4	25.3	13.7
25	24.6	48.8	58.8	22.1	29.3	16.8
30	28.5	54.9	65.6	26.1	33.6	20.2
35	32.6	61.4	72.8	30.4	38.2	23.9
40	37.0	68.5	80.5	34.1	43.2	27.8
45	41.7	76.0	88.7	40.1	48.5	32.1
50	46.7	84.0	97.4	45.5	54.2	36.7
55	52.0	92.6	106.6	51.3	60.2	41.6
60	57.7	101.6	116.4	57.5	66.6	46.9
65	63.8	111.2	126.7	64.1	73.4	52.5
70	70.2	121.4	137.6	71.2	80.6	58.6
75	77.0	132.2	149.1	78.8	88.3	65.0
80	84.2	143.6	161.2	86.8	96.4	71.8
85	91.8	155.7	174.0	95.4	105.0	79.2
90	99.8	168.4	187.4	104.4	114.1	86.9
95	108.3	181.8	201.4	114.1	123.6	95.2
100	117.2	195.9	216.2	124.3	133.7	103.9
105	126.6	210.7	231.7	135.1	144.3	113.1
110	136.4	226.4	247.9	146.5	155.4	122.9
115	146.8	242.7	264.9	158.6	167.1	133.3
120	157.7	259.9	282.7	171.3	179.3	144.2
125	169.1	277.9	301.4	184.7	192.2	155.7
130	181.0	296.8	320.8	196.9	205.6	167.9
135	193.5	316.6	341.2	213.7	219.3	180.7
140	206.6	337.2	362.6	229.4	234.4	194.1

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Job Sheet 14

Example: With a system using CFC-12, assume a suction pressure of 16 psig. Locate R-12 at the top of the chart on the previous page. Read down until you reach the suction pressure of 16 psig; since the chart shows 14.6 and 17.7 psig, we need to read left across the chart where 14.6 = 10°F and 17.7 = 15°F. Here, we interpolate between 10 and 15 to get a reading of 12.5 which we round off to 12°F; the temperature of R-12 at 16 psig is 12°F.

☐ 8. Subtract the reading in the previous step from the recorded suction line temperature.

Example: Using the 12°F reading in the previous example and a suction line temperature of 22°F, we subtract 22 – 12 = 10°F superheat.

☐ 9. Compare the computed superheat reading to the superheat reading specified by the TXV manufacturer; if they agree, the valve should be operating properly.

☐ 10. Check with your instructor to see if the TXV needs adjusting; most new TXVs never need adjusting and seldom need adjusting even after years of operation.

☐ 11. If an adjustment should be required, only a slight adjustment will be necessary, and it should be made only after the system has been operating at least several hours.

☐ 12. Make the adjustment by removing the seal cap over the valve stem and using the following procedure:

(a) To decrease the flow and increase the superheat, screw the valve stem in or clockwise.

(b) To increase the flow and decrease the superheat, screw the stem out or counterclockwise.

☐ 13. Be sure to tighten the adjusting stem packing nut and replace the seal cap tightly after making the adjustment.

Note: Some TXV types have non-rising stems and a change in adjustment DOES NOT change the position of the stem.

☐ 14. Wait 30 minutes after you complete the adjustment and take new readings.

☐ 15. Have your instructor check your work.

Job Sheet 14

☐ 16. Clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
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Job Sheet 15—Install a Core-Type Access Valve

Name ________________________________ Attempt Number ________

Date ________________________________ Overall Rating ________

Evaluation criteria	**Rating**
Valve installation area properly prepared	______
Valve core removed to avoid heat damage	______
Valve properly brazed in place	______
Core replaced and valve checked for proper operation	______

A. Tools and materials

Refrigeration system as selected by instructor
Core-type access valve
Valve core tool
Torch and striker
Silver alloy, silver brazing flux, and sand cloth
Clean, damp shop towel
Safety glasses and colored safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 3; it is a part of this activity.

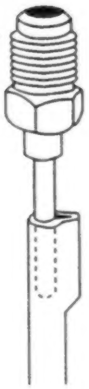
☐ 2. Put on safety glasses.

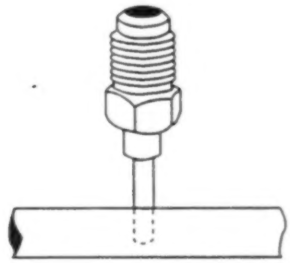
☐ 3. Clean an area on the tubing where the valve will be installed.

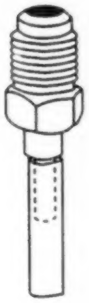
☐ 4. Remove the core from the valve.

Job Sheet 15

☐ 5. Place the valve on the tubing or in the pressure stub.







☐ 6. Apply silver brazing flux to the joint.

☐ 7. Put on colored safety glasses and light and adjust the torch.

☐ 8. Apply heat to the joint.

☐ 9. Apply the silver alloy.

☐ 10. Remove heat as soon as the alloy flows completely around the joint.

☐ 11. Turn the torch off; replace your colored glasses with regular safety glasses.

☐ 12. Clean the joint with a clean, damp shop towel, and be careful that moisture does not enter the system while you are cleaning or cooling the brazed joint.

☐ 13. Replace the core in the valve.

☐ 14. Have your instructor check your work.

☐ 15. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evaluating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 16—Install a Filter-Drier With Sweat Fittings

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

Evaluation criteria	**Rating**
Liquid line properly cut and cleaned	______
Filter-drier properly inserted	______
Nitrogen circulated through system during brazing	______
Brazing cleaned and filter-drier properly in-line	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set
Filter-drier with sweat fittings
Tubing cutter
Torch and striker
Silver alloy, silver brazing flux, and sand cloth
Nitrogen cylinder with regulator
Refrigeration ratchet
Clean, damp shop towel
Safety glasses and colored safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 3; it is a part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Install the manifold gauge set, if the set is not already installed.

☐ 4. If the system is under pressure, slowly release nitrogen pressure, recover refrigerant, or pump down.

☐ 5. Use sand cloth to polish the liquid line prior to cutting it.

Job Sheet 16

☐ 6. Cut the liquid line at a location approved by your instructor.

☐ 7. Check for the proper direction of refrigerant flow.

☐ 8. Cut and remove the old filter-drier, or cut and remove a section of the liquid line equal to the length of the new filter-drier.

☐ 9. Polish the ends on the liquid line again after you cut them.

☐ 10. Apply flux to the polished ends.

☐ 11. Remove the protective cap from one end of the filter drier.

Note: On some small domestic refrigeration systems, the protective ends have to be cut off with a tubing cutter.

☐ 12. Insert the liquid line into one end of the filter-drier.

☐ 13. Twist the filter-drier while inserting the line to insure a good coating of flux all around the joint.

☐ 14. Remove the protective cap from the other end of the filter-drier.

☐ 15. Twist the filter-drier while inserting the other end of the line.

Note: When installing a capillary tube into a filter drier, special precautions are required, and that procedure is covered in a separate job sheet.

☐ 16. If you're installing a filter-drier with a core-type valve, remove the core to prevent heat damage.

☐ 17. Attach the nitrogen cylinder to the manifold gauge set.

☐ 18. Adjust the nitrogen cylinder to 2 psig.

☐ 19. Allow nitrogen to circulate through the system.

☐ 20. Put on colored safety glasses and light and adjust the torch.

☐ 21. Heat the joint by manipulating the flame away from the joint.

☐ 22. Apply silver brazing alloy.

Note: Cadmium-free silver brazing is recommended for this activity.

☐ 23. Silver braze the other end of the filter-drier/liquid line.

Job Sheet 16

☐ 24. Turn the torch off.

☐ 25. Clean both brazed ends with a damp shop towel before the joints cool.

☐ 26. Check both joints to be sure all flux residue has been removed.

☐ 27. Have your instructor check your work.

☐ 28. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____________________

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 17—Leak Test a Refrigeration System With an Electronic Leak Detector

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set properly set up	______
Leak detector properly set up and adjusted	______
Liquid leak detector used as needed	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set
Electronic leak detector and operator's guide
Liquid leak detector as required
Open end wrench and refrigeration ratchet
Safety glasses

B. Procedure

☐ 1. Read the Operator's Guide for the electronic detector so you will know how to set it up and adjust it properly.

☐ 2. Make notes for any materials you may need to complete the Service Work order in Assignment Sheet 3; it is part of this activity.

☐ 3. Put on safety glasses.

☐ 4. Attach the manifold gauge set to the system, if it is not already attached.

☐ 5. Crack the system service valves, if necessary.

☐ 6. Allow pressures to equalize.

☐ 7. Turn on the leak detector.

☐ 8. Allow the detector sufficient time to warm up.

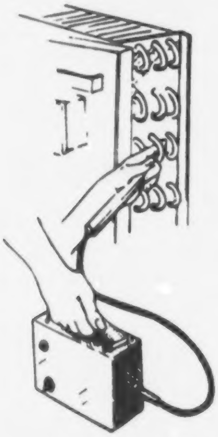
Job Sheet 17

☐ 9. Adjust the detector according to the Operator's Guide.

☐ 10. Check the system area for obvious concentrations of leaking refrigerant that could cause the detector to give false readings or maybe damage the sensor.

☐ 11. Hold the probe underneath and close to the suspected leak area.

Note: Any connection could be suspected of leaking, but a good place to start would be with the mechanical connections, coils in the evaporator and condenser, and connections around the compressor where system vibration is most likely to loose connections.



☐ 12. Watch or listen for the detector to indicate a leak.

☐ 13. Note the location of any leak you find.

☐ 14. Turn the detector off.

☐ 15. Use liquid leak detector to double check the leak(s) you found, and be sure to clean the leak detector off after use.

☐ 16. Have your instructor check your leak testing procedure.

☐ 17. Check with your instructor about continuing with another activity, or clean up the area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 18—Evacuate a Refrigeration System and Verify Vacuum Level With a Mercury Manometer

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set and vacuum pump properly set up	______
Mercury manometer properly attached to system	______
"No Venting" regulation effectively applied	______
Triple evacuation completed and verified	______
Service form properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set, vacuum pump, and mercury manometer
Open end wrench and refrigeration ratchet
Safety glasses
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work order in Assignment Sheet 3; it is part of this activity.

☐ 2. Attach the manifold gauge set to the system, if it is not already attached.

☐ 3. Crack the system service valves, if necessary.

☐ 4. Purge any leak testing pressure that may be left in the system.

Caution: "De minimus" venting regulations apply to this activity!

Job Sheet 18

☐ 5. Connect the center hose of the manifold gauge to the vacuum pump inlet port.

☐ 6. Attach the mercury manometer to the system.

☐ 7. Remove the cap from the vacuum pump outlet port, if necessary.

☐ 8. Start the vacuum pump.

☐ 9. Open the high side valve on the manifold gauge set.

☐ 10. Open the low side valve on the manifold gauge set when the compound gauge shows a vacuum of 5″ Hg or more.

☐ 11. Evacuate until the mercury manometer reads .4″ or 29.52″ hg.

☐ 12. Continue to evacuate for 20 minutes after obtaining a reading of 29.52″ hg.

☐ 13. Close the manifold gauge valves.

☐ 14. Disconnect the center hose from the vacuum pump.

Caution: "De minimus" venting regulations apply to this activity!

☐ 15. Allow the system to sit for 15 minutes, and observe the mercury manometer; if the vacuum level changes, system moisture is still present or a leak exists, and you need to pressurize the system to 5 psig with R-22 and repeat steps 5 through 16, or repair the leak and repeat steps 5 though 16.

Caution: "De minimus" venting regulations apply to this activity!

☐ 16. Have your instructor check your work and verify that the system is ready to charge with the proper refrigerant.

☐ 17. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 19—Liquid Charge Using a Charging Cylinder

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set properly attached to system and cylinder	______
Liquid properly charged into system	______
"No Venting" regulation effectively applied	______
System pressures stabilized to indicate proper charge	______

A. Tools and materials

Refrigeration system as selected by instructor
Manifold gauge set
Charging cylinder with proper refrigerant
Clean shop towel
Safety glasses

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 3; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Turn on charging cylinder heater, if it has one, and allow it to heat until the pressure reaches 150 psig.

☐ 4. Connect the manifold gauge set to the system if it is not already attached.

☐ 5. Connect the center hose of the manifold gauge set to teh charging cylinder.

☐ 6. Open the charging cylinder valve.

☐ 7. Purge the center hose at the manifold, and other hoses at the manifold if the system has core-type access valves.

Note: Never purge hoses which contain a vacuum.

Job Sheet 19

☐ 8. Open the manifold gauge set valves.

☐ 9. Purge the refrigerant hoses at the service valve gauge ports.

Caution: "De minimus" venting regulations apply to this activity. Wear safety glasses and use a shop cloth around the fitting to prevent refrigerant from spraying on your skin.

☐ 10. Close the manifold gauge set valves.

☐ 11. Crack the system service valves.

☐ 12. Open the high side valve on the manifold gauge set.

☐ 13. Allow liquid refrigerant to enter the system.

☐ 14. Close the high side manifold gauge set valve approximately 15 seconds after all refrigerant has entered the system, and turn off the heater.

☐ 15. Disconnect the center hose from the charging cylinder.

☐ 16. Start the system.

☐ 17. Run the system long enough to allow pressures to stabilize.

☐ 18. Have your instructor check your work.

☐ 19. Back seat the system service valves.

☐ 20. Purge hoses of refrigerant by opening the manifold valves and allowing the refrigerant to discharge through the center hose.

Note: On systems using core-type access valves, the hoses cannot be purged of refrigerant prior to removing them.

☐ 21. Remove the manifold gauge set and plug the hoses.

☐ 22. Replace and tighten all valve caps.

Job Sheet 19

☐ 23. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 20—Vapor Charge a Refrigeration System From a Refrigerant Cylinder

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Manifold gauge set and refrigerant cylinder properly set up	______
Weight of refrigerant cylinder recorded properly	______
System started and checked for stabilized pressures	______
Amount of refrigerant used properly determined	______
Service work order properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Refrigerant cylinder and scales as selected by instructor
Manifold gauge set and P/T chart for refrigerant
Open end wrench and refrigeration ratchet
Safety glasses and shop towel
Service form and pen or pencil

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work Order in Assignment Sheet 3; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Connect the manifold gauge set to the system service valves, if not already attached, and attach the center hose to the refrigerant cylinder.

☐ 4. Set the refrigerant cylinder in an upright position on the scales.

☐ 5. Open the cylinder valve.

note: If the system has been evacuated, skip to Step 9.

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☐ 6. Open the manifold gauge valves and purge the refrigerant hoses at the service valve gauge ports, or if the system has core-type access valves, purge the hoses at the manifold.

☐ 7. Close the valves on the manifold gauge set.

☐ 8. Crack the service valves on the refrigeration system.

☐ 9. Record the weight of the refrigerant cylinder here ______, and use this same figure on your service form.

☐ 10. Open the high side of the manifold gauge set.

☐ 11. Allow vapor to enter the system until pressures equalize.

☐ 12. Close the high side valve on the manifold gauge set.

☐ 13. Start the system and allow it to run until pressures stabilize.

☐ 14. Crack the low side valve on the manifold gauge set to allow refrigerant to enter the system.

☐ 15. Allow the pressure gauge reading to increase to 20 to 30 psig above system pressure.

☐ 16. Check your P/T chart to determine approximate pressure.

☐ 17. If the system has a thermostatic expansion valve, stop charging when the sight glass clears of bubbles to indicate liquid is reaching the metering device.

☐ 18. If the system has a capillary tube as a metering device, stop charging when you reach operating pressures specified in manufacturer's literature or pressures from a standard P/T chart.

☐ 19. Allow system to run until pressures stabilize.

☐ 20. Recheck pressures or sight glass and add more refrigerant as required.

☐ 21. Back seat the system service valves.

☐ 22. Record the "after charging" cylinder weight and record it here ______ and on your Service Work Order in Assignment Sheet 3.

☐ 23. Figure the amount of refrigerant used and record it here ______ and on your Service Work Order in Assignment Sheet 3.

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☐ 24. Have your instructor check your charging procedure.

☐ 25. Replace and tighten all caps and service ports.

☐ 26. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ____

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Evacuating, Pressurizing, Leak Testing, and Charging
Unit 16

Job Sheet 21—Use Suction Line Temperature/Pressure Parameters to Evaluate a System Charge

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Thermometer properly attached to suction line	______
Manifold gauge set properly installed	______
Ambient temperature reading accurately made	______
System charge evaluated from temperature/pressure parameters	______
Service Work Order properly completed	______

A. Tools and materials

Refrigeration system as selected by instructor
Thermometer with remote sensing bulb
Ambient temperature thermometer
Manifold gauge set and P/T chart for refrigerant
Tape or Velcro strap to secure thermometer remote bulb to suction line
Pipe insulation to wrap around sensing bulb
Safety glasses and a shop towel

B. Procedure

☐ 1. Make notes of any materials you may need to complete the Service Work order in Assignment Sheet 3; it is part of this activity.

☐ 2. Put on safety glasses.

☐ 3. Attach the thermometer sensing bulb securely to the suction line where it enters the condensing line, and insulate it with pipe wrap.

☐ 4. Attach a manifold gauge set to read pressure at the suction line port of the condensing unit.

☐ 5. Start the unit and allow line pressures to stabilize for at least 15 minutes.

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☐ 6. Read and record the following:

(a) Suction line pressure: ______

(b) Ambient temperature: ______

(c) Suction line temperature: ______

☐ 7. Read across and down on the following superheat charging chart until you find the intersection that displays the temperature that your recorded line temperature should be.

Suction Line Temperature/Pressure Parameters

OUTDOOR AMBIENT (°F)	SUCTION PRESSURE AT OUTDOOR SECTION (PSIG)																								
	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
	SUCTION LINE TEMPERATURE (± 3°F.)																								
65	37	42	47	53	59	64	69	71	75	79	82	85													
70	32	37	43	48	53	59	64	69	71	75	79	82	85												
75		33	38	43	49	54	59	65	69	72	76	79	83	85											
80			32	38	43	48	54	59	64	69	72	75	79	81	85										
85				32	38	41	48	53	58	64	69	71	75	78	81	84									
90						35	40	47	52	57	62	65	68	72	75	78	81	85							
95								40	44	49	54	59	62	66	70	73	76	79	82	85					
100										44	48	53	58	63	65	69	72	75	78	81	85				
105											42	47	50	55	60	66	69	71	75	78	80	83	86		
110													45	50	55	60	65	68	70	73	76	79	82		
115															51	55	60	63	66	69	72	75	78	81	84

Example: At 90°F outdoor temperature and at 68 psig suction pressure, the system will be correctly charged if the recorded suction line temperature is between 54°F or 60°F; this equates to 57°F + 3°F.

☐ 8. Should the suction line temperature read more than 3° above or below the chart reading, the system needs to be evaluated to determine the nature of the problem.

☐ 9. If the intersection figure falls into the blank area left or right on the chart, check the system for:

(a) Low indoor unit airflow.

Job Sheet 21

(b) Low outdoor unit airflow.

(c) Refrigerant line restrictions.

(d) Dirty filter and/or dirty evaporator coils.

(e) Dirty or blocked condenser coils.

(f) Other abnormal conditions.

☐ 10. If the system application appears to be correct, and the unit suction line temperature is not within the 3° limit above or below the chart figure, the system is improperly charged and should be corrected according to the following parameters:

(a) If the suction line temperature is higher than the given value, the system is undercharged.

(b) If the suction line temperature is lower than the given value, the system is overcharged.

☐ 11. Adjust or change system parameters as your instructor directs.

☐ 12. Close the high side valve on the manifold gauge set.

☐ 13. Turn the system off.

☐ 14. Indicate in a brief statement your evaluation of the system charge, including any recommendations for needed corrections.

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☐ 15. Have your instructor check your work.

☐ 16. Check with your instructor about continuing with another activity, or clean up area and secure tools and equipment.

Evaluator's comments: ______________________________

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